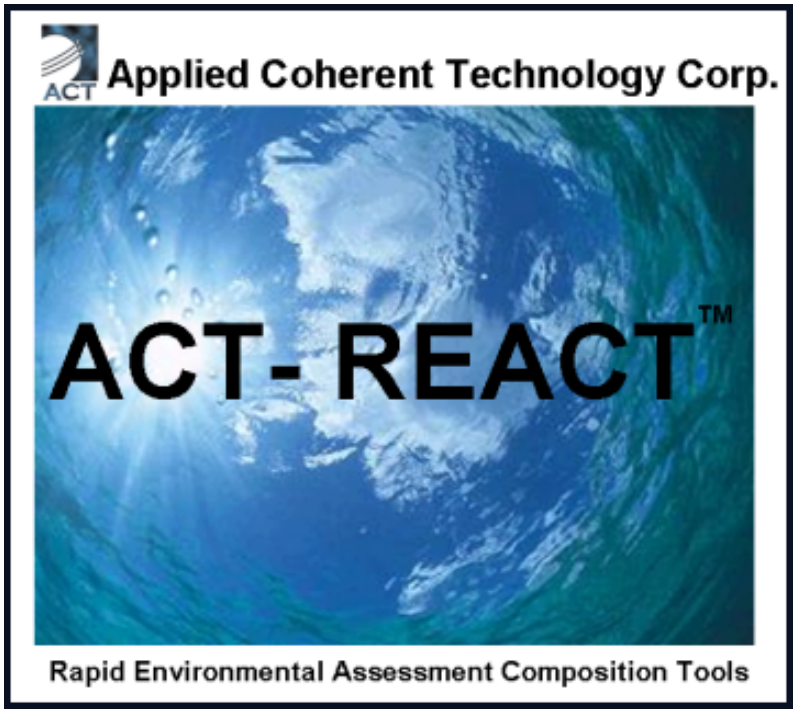
ACT-REACT User's Manual

Part II – MSHELL Development Environment



MSHELL, an Image and Signal Processing Language.
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ProVIEW, a Professional Virtual Image Processing Environment for Windows.
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QWT - MDI plotting capabilities are based in part on the work of the **Qwt** project (**http://qwt.sf.net**)

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Overview

What Is the ACT-REACT?

ACT-REACT stands for ACT's Rapid Environmental Assessment Composition Tools. It provides a number of high level tools, e.g.

- Network Centric Data Access to Multiple Planetary Projects/Missions
    - Cartographic Viewer
- Development Environment,
- Decision Support Tools

This document concentrates on the development and analysis tools of ACT-REACT, i.e. MSHELL.

*A core component of ACT-REACT's development environment is the interface with ACT's **MSHELL** image/signal processing interpreter language. The ACT-REACT GUI interface to MSHELL inherits many of the concepts from ProVIEW[1].*

*ACT-REACT&MSHELL is **supported on all the key operating systems**, e.g. MS-Windows, MAC-OS (INTEL), LINUX (INTEL)*

The combination of ACT-REACT&MSHELLexposes an interactive command line and menu driven Image and Signal Processing Environment which runs under all major OS environments. It provides powerful scientific image and signal processing and visualization capability by affording you:

- Algebraic and matrix operations using mathematically intuitive syntax.
- Support of relational operators and flow control through the built-in ACT's MSHELL image/signal processing interpreter language.

[1] *ProVIEW is no longer supported by ACT and it has been replaced by ACT-REACT.*

- Double precision image processing computations for high accuracy which support both real and complex number operations.
- Over 300 operators: FFT, convolution, edge detection....
- Geometric operations: re-size and rotate images using unequal horizontal and vertical scaling.
- The ability to call your own functions as stand alone executables, or Dynamic Link Library (**DLL**) for MS-Windows implementations.
- The ability to access **SQL** database engines via **ODBC**, or **SQLITE**.
- Flexible multiple document interface (MDI) for the display of images, plots, and scripts.
- Contrast processing, linear stretching, intensity range remapping.
- Pseudo Color Lookup Tables for each Image with as many colors as the hardware permits.
- Interactive graphics, i.e. 2D, 3D, and Contour Plots.
- Ability to support multiple image format support: ASCII, 8 bits/pix, floating point, in addition to key standard formats, such as TIFF, BMP, FITS, PGM, PPM, PDS, …
- Interpreter access to many industry standard geo-data-formats via the open-source Geographic Data Abstraction Library (**GDAL**).
- Ability to project geo raster data to any of the standard USGS cartographic map projections.
- ACT-REACT and MSHELL are the software development tool-kit for ACT's: WWW Information Processing Environment (**WIPE**), and Planetary Information Processing Environment (**PIPE**).
- Flexible editing and interactive debugging environment.
- Support to Grid computing, via ACT's ACT-REACT GRID (**ARG**), which allows multiple instances of the MSHELL engines to be running over a heterogenous cluster. All communications are done via SOAP interfaces

Expert or novice, independent of your experience, ACT-REACT&MSHELLallows you to manipulate images and signals in a simple manner, releasing you from the constant tracking of image attributes such as image dimensionality.

ACT-REACT&MSHELLpermits you to process a large volume of images in a fully automatic fashion, e.g. large scale reduction, calibration and analysis of satellite based digital images.

If you work with NASA's Planetary Data System (**PDS**) data, ACT-REACT&MSHELLenhances your productivity by providing the following additional capabilities:

- Adoption of the PDS reader libraries
- Virtual Image **variable** which can be bigger than 4Gbytes!

- Bindings to the NAIF/**SPICE** library, for rapid prototyping of geometry computations associated to planets and planetary missions.

Who Should Use MSHELL?

MSHELL has been developed by and for professionals working in the areas of image and signal processing who desire to concentrate on algorithmic development and data visualization rather than on low level programming.

MSHELLcan significantly reduce the time required for the development and implementation of image and signal processing algorithms without sacrificing computational performance. A single statement in MSHELL can be equivalent to a large number of statements in other languages, such as C or FORTRAN. ACT-REACT's GUI components allows to rapidly visualize the data expediting the process of algorithm development.

Based on the understanding that both image processing and multi-dimensional signal processing share the same mathematical foundations, MSHELL was developed from the onset as an image and signal processing language. With MSHELL at it's core, **ACT-REACT provides an Image and Signal Processing Environment** that is powerful, compact, and simple to use. This makes ACT-REACT an excellent tool for work in many diverse application areas, such as:

- Calibration and Reduction of Satellite Imagery, (coherent as well as non-coherent image data),
- Visualization of Multi-Spectral Image Data - in sensor projection space or cartographic space,
- Modelling of Electro-Optical Imaging Systems
- Decision Support Tools

To effectively use ACT-REACT&MSHELL a working knowledge of Linear Algebra, Image Processing, and Computer Programming is recommended.

ACT-REACT's Development Environment

ACT-REACT Analysis and Development Environment

To use ACT-REACT / MSHELL development environment some familiarity with the Graphical User Interface (GUI) is assumed. This is discussed in more detail in a companion manual that address the GUI and ACT-REACT's targeting capabilities.

With ACT-REACT&MSHELLyou can have multiple images open at the same time, i.e. multiple document interface (MDI). However, you will note that at any given time only one of these windows will be the **Active Window**, i.e. the window with the highlighted top bar. In Figure 1 the left image is the active window.

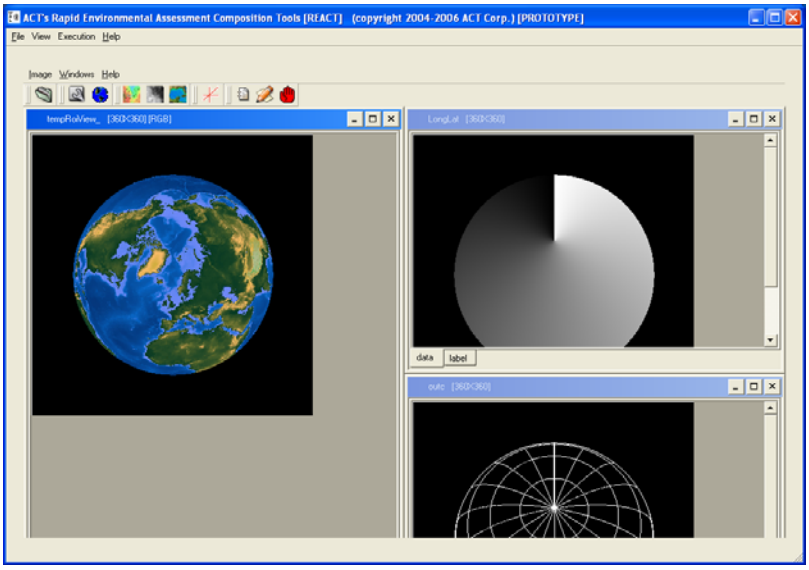

ACT's Rapid Environmental Assessment Composition Tools [REACT] (copyright 2004-2006 ACT Corp.) [PROTOTYPE]
File View Execution Help
Image Windows Help
data
label

Figure 1 - Sample ACT-REACT&MSHELLscreen.

The are a number of panels that are directly related to the use of ACT-REACT/MSHELL. These are briefly introduced below.

Monitoring Panel

The Monitoring Panel provides a simple way to send single commands to the interpreter, and capture all text output it returns, see right panel on the image below.

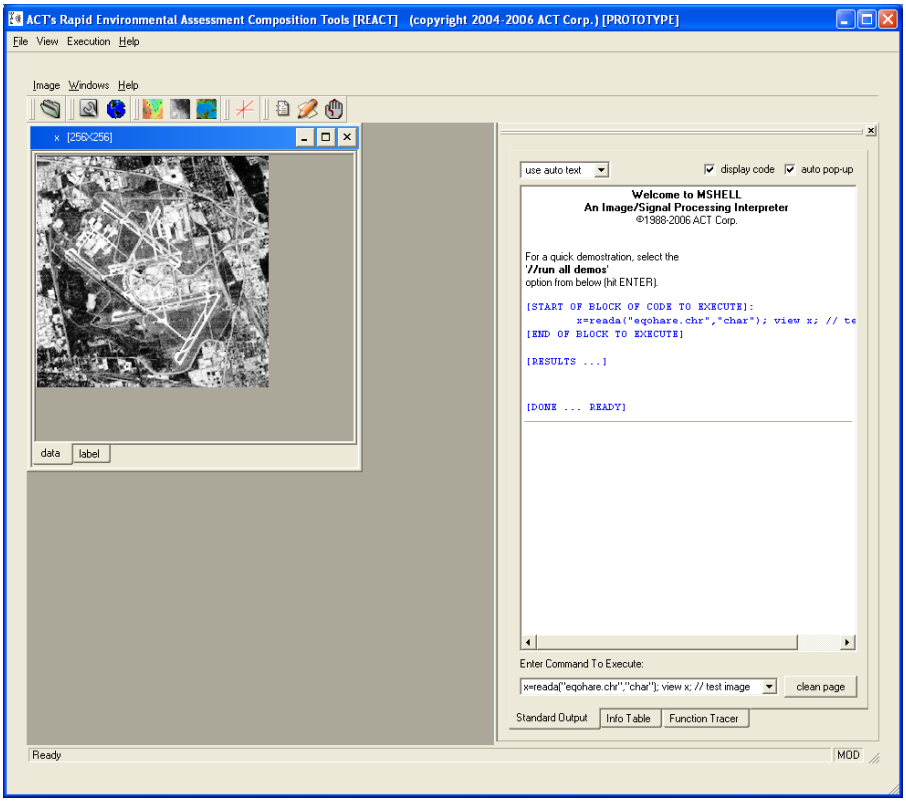


Figure 2 Monitoring Panels is on the right and Multiple Document Interface (MDI) for images on the left.

The user can toggle the view of the Monitoring panel from its corresponding tool bar icon, i.e. . Commands typed in the 'Command To Execute' text region, are submitted and executed by the MSHELL interpreter. It is from within this window that script files can be manually invoked, see "**MSHELL Script Files (.msf,.msh,.vsh)**" on page 37. Also, any text output is normally sent to this window. Note that in ACT-REACT many of the GUI commands are converted directly to commands in the "**MSHELL Interpreter Language**", described in page 22.

In addition to the Monitoring Panel, the user can send commands to MSHELL using the Scripts Tool Panel, . This will be discussed in a later section.

Image Window

Prior to enabling the display of an image the user can control many attributes that will affect how the image is to be displayed

An image window provides a visual representation of a two dimensional array of numbers. The simplest way to enable the view of an array is using the 'view' command. In ACT-REACT&MSHELLthere are several different ways to enable an image window for the display of an existing array variable:

- from the Command Shell Window using the **'view'** command, see **Appendix B**,
- or from the OpenImage toolbar icon, . This will open the OpenImage Panel, i.e.,

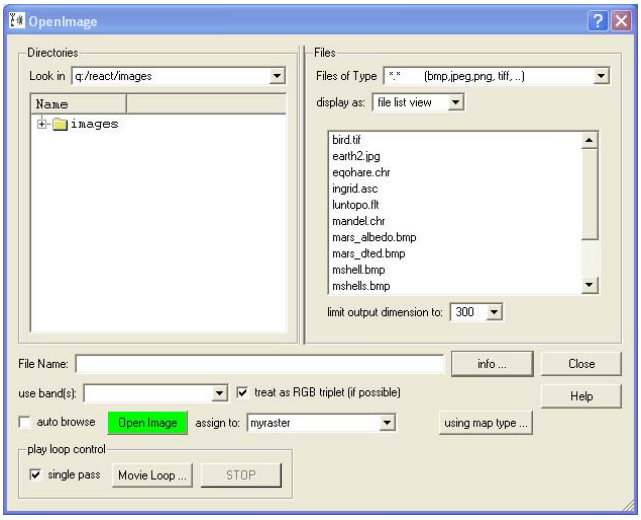


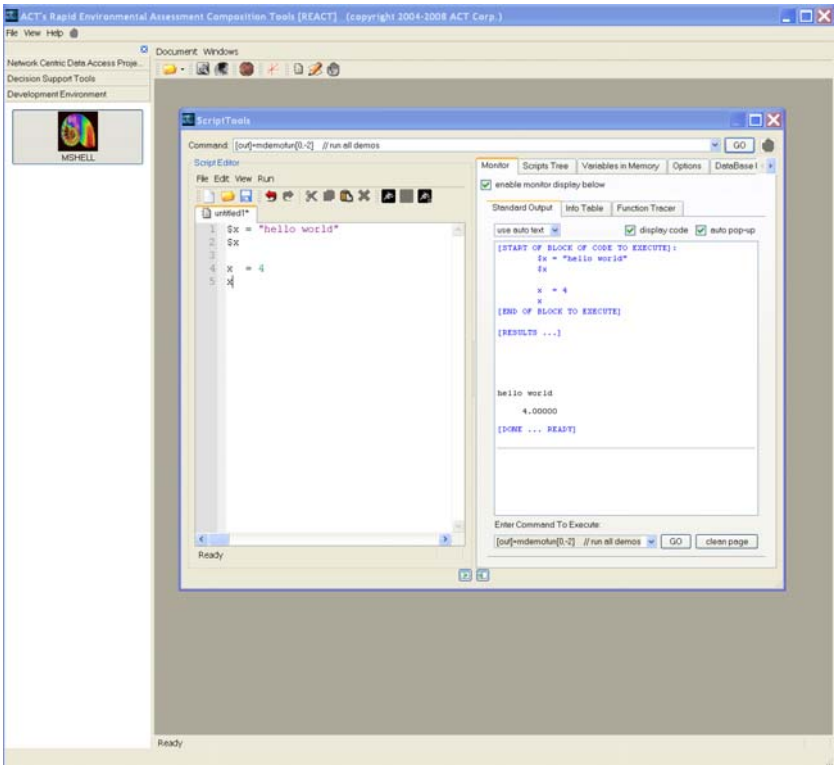
Figure 3 Use this panel to navigate and select an image to open. Many file formats are supported, e.g. JPEG, PNG, TIFF, … , Geo-data-formats, …, NASA's Planetary Data System Data formats.

Once the image is open, you can exercise a good deal of control over how it is displayed. Additionally, you can use the scroll bars that are part of the image window to slide the image horizontally or vertically, or use the cursor to travel over the image. Notice that as you move the cursor over the image, it's row position, column position, and corresponding pixel value are tracked in the status bar at the bottom left of ACT-REACT's Main Window. If cartographic or geographic coordinates information is available, it will also be displayed.

Script File Window

In a Script File Window you can create, edit, or display a text file of MSHELL commands. The easy to use built in editor supports the standard Cut, Paste, Search, and Replace operations found in most windows applications.

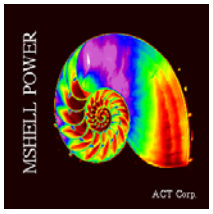
Once in the development environment, the Scrip File Window can be enabled for access via its associated icon, i.e. . Multiple scripts windows can be openened at the same time. In each script window the user has accessible a full editing screen (based on the Scintilla editor).



Executing a Script File From the Graphical User Interface

You can trigger the execution of code in the window using the RUN icons, i.e.:

- Run selected code (only runs highlited code)
- Run all code (runs all code in the script window)
- Run Demo code (runs embedded demo code, it is exists)
  Most of the script functions in the MSHELL tree have embedded demo code.



MSHELL Interpreter Language

Language Syntax

Introduction

At the heart of **ACT-REACT** is the **MSHELL** interpreter developed by ACT. MSHELL is a **32** or **64** bit image/signal processing language which allows you to perform complex operations using a simple syntax.

The MSHELL scripting language has a simple syntax. If we need to compare it to other scripting languages, then it is closer to Matlab than to IDL.

The following sections will provide detail information on the language syntax followed by a detail description (in the appendices) of all the built-in internal function.

Variable Names and Types

Hint: Use the 'show' command to get a list of all the variables loaded in memory

In general, a variable name can be any alphanumeric string starting with a letter followed by a combination of letters and/or digits. The following are legal alphanumeric variable names,

x,
x10,
OutputImage

Note that variable names should be kept under ***15 characters***.
Additionally there are a number of reserved keywords and symbols, used

by the interpreter, that cannot be used as variable names. A list of these keywords together with a description of their use is found in the section "**Appendix A** (List of Internal Functions).

There are four basic types of variables:

- Array variables (holding floating point numbers)
- String variables (holding character strings)
- System variables (used to control the interpreter environment)
- Virtual Variable (mostly used internally by MSHELL)

Array Variables

The basic variable in MSHELL's interpreter is a **two dimensional array structure**. More specifically, if '**a**' is the name of an array, then it points to an array structure of the form,

Throughout most of this manual the terms image, array, or matrix can be interchanged without loss of generality

$$a \rightarrow \begin{pmatrix} a_{0,0} & a_{0,1} & \cdots & a_{0,I-1} \\ a_{1,0} & a_{1,1} & \cdots & a_{1,I-1} \\ \vdots & \vdots & \cdots & \vdots \\ a_{J-1,0} & a_{J-1,1} & \cdots & a_{J-1,I-1} \end{pmatrix}$$

The upper left element in an image or array is denoted as element (row=0,col=0).

where J is the number of rows in the array, and I is the number of columns.

The MSHELL array structure follows the convention that array indices start at zero. Having the basic variable as a two dimensional array provides a unified way to treat scalars, one dimensional signals, and two dimensional signals (images). MSHELL array variables may be either real or complex valued (i.e. hold imaginary numbers). This is particularly advantageous in Fourier transform computations.

The following are valid statements followed by single line comments ('//') :

```
x = randu(5,10)     // generate an array of random numbers

x(0,0)              //extract element value at row=0,column=0
x(1,2:3)            // extract elements 2 and 3, on row 1
x(:,4:6)            // extract all values between columns 4&6
                    // and for all rows
```

```
x(2,:)          // extract all column values for row 2
y = x(1:3,2:5)  // extract values from rows 1 to 3  and
                // columns 2 to 5.
                // Assign result to variable 'y'
```

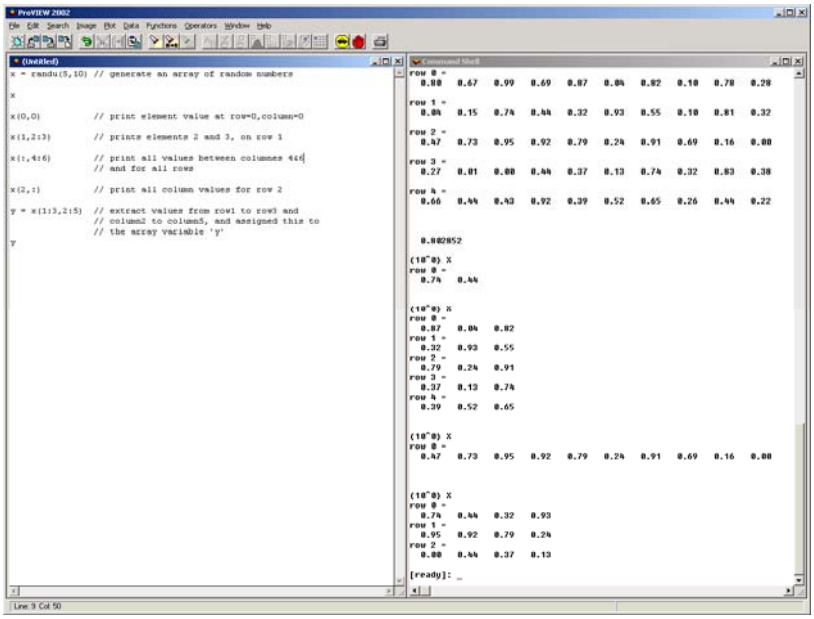


Figure 4 Retrieving array values using row andcolumn ranges.

There are different schemes that facilitate the reading from , or writing to, an array variable. These are discussed in the **Region of Interest Manipulation** section , on page 30.

Note: Included in the region of interest manipulations is a special case that extends the 2D array into a 3D representation for easy visualization and manipulation, which is quite useful for working with hyperspectral data.

For formatted printing of array values see the 'float2str' function.

Intrinsic Attributes Associated with Array Variables

Array variables have intrinsic attributes that can be inspected and changed by the user.

If 'x' is an array all the majority of the intrinsice array attributes are accessed via, `x.m_[attribute name]`. See the **Intrinsic Attributes Associated with Array Variables** section **,** *page 63* , for more detail.

By controlling these attributes the user can access data in memory as a 1-d array, or 2d-array or 3d-array (in band-sequential-mode). See the builtin functions **`alternateRGB`**() and **`alternateBSQ`**() for a description on how to access data as a 3d-cube.

String Variables

A string is defined as a sequence of alpha numeric characters enclosed within quotes (similar to the 'C' language).

In general, string variable names start with '**$**'. For example, the string variable `$message` can be assigned a string as follows,

$message = "hello world";

MSHELL allows the use of control characters within a string, such as

\n	linefeed
\t	tabulation
\b	backspace
****	backslash
\r	carriage return

The above control characters can be used to control the format of strings on the output.

If `$x` is a string, and r1,r2 are row numbers, and c1,c2 are column numbers, its content can be accessed using the following syntax

```
$x(c1:c2)        // select characters between column c1 and c2,
                 // independent of any linefeeds or row number.
                 // if c2 is greater than the length of $x, the substring
                 // from c1 up to the end of $x is returned.
                 // If both c1 and c2 are out of bounds, an error is raised.
                 // This notation is particularly fast in
                 // execution since it does
                 // not require to make two passes over the
                 // string.
$x(r1, c1::c2)   // select characters between columns c1
                 // and c2 in row r1
$x(:, c1:c2)     // select all characters in all rows
                 // between columns c1&c2
$x(r1,:)         // select all characters in row # r1
```

If 'a' is a row vector, say a=(0,3,1), then

```
$x(a,: )         // extracts all the lines specified by
                 // the list in 'a'
$x(a,c1:c2)      // extracts all the lines specified
                 // by the list in a ,
                 // but only the characters between
                 // column c1&c2.
```

Note: Relational Operations are permitted on strings. See Program Flow Control for more info.

System Variables

The majority of the system variables are used for plotting purposes by the ‘plot’ and ‘plot3d’ functions. Others are used to control the behaviour of ACT-REACT&MSHELLand to hold basic system configuration information. A complete list of these variables can be found in the dictionary of internal functions under M_.

Some of the ACT-REACT&MSHELLsystem variables are strings while others are numbers. All system variables are prefixed by 'M_'. String system variables do not require the ‘$’, they are a special case. For example, to initialize the x-axis label to the string “Time” use

```
M_xlabel="Time";
```

Virtual Variable 'V'

MSHELL has a special variable, 'V', called the virtual variable. With this variable the user can manipulate an image file which can be as large as 2^64 pixels! It supports many formats: 1bytes/pixel, floating point, double precision, unsigned integer, …

If the user has a huge image in a file or is going to be working with an image that can not be easily held in memory, then he or she can still manipulate pieces of the large image using MSHELL’s virtual variable.

Only one image file can be associated at any given time with the virtual variable V. The basic virtual related functions in MSHELL are Vopen, Vclose, and Vnew().

Vopen - Links 'V' to an image file,

Vclose - Stops link between 'V' and a disk file,

Vnew - Creates a new virtual file.

See Appendix B for detailed usage of the above virtual variable manipulation functions.

Once a link is established between a file in disk and the virtual variable 'V', then the user can access rectangular regions of interest in the disk file for read or write operations (the user must always provide a rectangular region of interest when writing or reading from 'V').

MSHELL expressions (or statements)

A statement is, in general, an expression involving variables, internal functions, and calls to script functions. Multiple statements can be typed in the same physical line if they are separated by a semicolon. For example,

```
[ready]: x=4; y = x+4; z=cos(y);
```

is a legal statement. A statement may expand over more than one physical line if a delimiter '\\' is used to indicate a continuation line, e.g.

```
x =   cos(x+y)  \\
        +   sin(x-y)
```

Tabs, spaces, and linefeeds are ignored by the interpreter. An intuitive mathematical syntax is followed by the interpreter, allowing you to input the expressions in a form similar to the their actual mathematical representation.

In general, expressions which do not involve an assignment will print the result to the screen, e.g.,

```
[ready]: 3+4
7
```

A broad representation of numbers consistent with most computer languages is allowed. The following are valid number representations:

4 0.1 44. 0.44 34.89E4 34.89e10

Calling Syntax for Numeric Functions

The output of most of the numeric functions can be used as direct inputs to other numeric function, e.g.

X = abs(log10(fft2(x)))

Notice that you do not have to worry about the implicit dimensions of x and if it is either real or complex. If a function can not handle a complex input it will return an error message.

For the specific example above, since all functions are taking only one input argument, it can be written as

X = x.fft2.log10.abs // the operations are applied on 'x' from left to right

Functions that take only one argument are denoted as unary functions.

Unary Numeric Function Syntax

In general, when using a function with only one input argument, a MSHELL unary function, the following two statements are equivalent,

```
ufun(varname)          same as          varname.ufun
```

For example, if x is an array variable the following two lines are equivalent,

```
y = cos(mean(x))       same as          y = cos(x.mean)
```

The notation in the second line allows us to look at the mean value as an attribute of x. Also, unary function syntax in dotted notation can be used wherever an ARRAY variable is returned, as in:

```
randu(10, 10).mean
```

This special syntax also allows to concatenate dotted notation thus creating multiple unary function calls within the same statement:

```
randu(10, 10).sumr.max      // returns the maximum value resulting  from the
                            // from the sum of all rows
```

Note: If you are working with large arrays and the same computation is needed multiple times, then it is better to save the result in an intermediate variable. For example, if 'x' is a large array, then

```
y = ltclipto(x,x.max, x.max/2)
```

can be computed faster if *written* as,

```
xtheshold     =     x.max/2;
y             =     ltclipto(x,xthreshold, xthreshold/2)
```

Comments Delimiters

Statements enclosed between ***/**** and ****/*** are ignored by the interpreter. This is used to place comments in a script file or to prevent the execution of the line or lines between the comment delimiters.

For example, a valid group of statements that make use of comment delimiters is,

```
/* Compute the magnitude of the FFT
     on image  x
*/
x = abs(fft2(x))  // another way to crete a comment
```

The delimiter '***//***' can be used to create single line comments

Operator Type and Precedence

The following operator symbols are defined within MSHELL. Most of them are used in algebraic operations. The precedence of operators increases as we move down the list, with operators within the same line having the same precedence.

=	assignment operator
::	row augmentation or string concatenation
#	column augmentation
+ -	array addition and subtraction
*** / *. /.**	multiplication and division (elemental)
^	a^b, "a to the power of b"
-	unary minus, e.g. -x
'	transpose operator, e.g. x'
f	an internal function, e.g. cos()

Hence, in the expression

```
c = a+b*x;
```

the multiplication is performed prior to the addition.

Proper use of parenthesis can result in a significantly faster execution

The user can use parenthesis to force grouping of terms and override the operator precedence. The use of parenthesis for grouping can result in faster code execution. For example, consider the following two expressions,

```
x = (a/b)*c;
x = a*(c/b);
```

if *a* and *b* are scalars, and *c* is a large 2 dimensional or 1dimensional array, the grouping, *(a/b)*c* , executes significantly faster since it involves fewer operations.

In the implementation of array assignments, MSHELL uses the concept of **copy-on-write** (sometimes referred to as "COW"). Copy-on-write is a memory optimization strategy. The fundamental idea is that multiple assignments, say 'x=y; q=y' are pointing to the same location of memory used by 'y'. This pointing scheme is maintained until an operation tries to modify any element in an array, say 'x(0,0)=3', that it is being shared. At this point a private copy of the memory pointed by 'x' is first created then modify to prevent the changes affecting the other arrays. All of this happens transparently to the user. The primary advantage is that memory usage is maintained low until it is absolutely necessary to allocate more memory.

Region of Interest Manipulation

MSHELL supports two types of regions of interest: rectangular regions of interest (**ROI**), and non-connected regions of interest, also called generalized regions of interest (**GROI**). ROIs provide a simple way to refer and access rectangular regions within an image, while GROIs provide a simple way to refer to a list of pixels in an image as an entity.

ROI

A **rectangular region of interest** can be constructed in the following ways:

- Using the window definition function, e.g.

  roi = wdef(row0, col0, nrows, ncols);

- Interactively, using the mouse. This option is selected using the IMAGE|SET-ROI menu option.

If the **ROI** is a valid region of interest, it can be used as an argument of a MSHELL variable. Regions of interest can be specified in any of the following operations,

- Assignments,

  x(wmove(roi,25,40)) = x(roi);

- Within expressions,

  x(roi) = y(roi)+z(roi)-q(roi);

GROI

Generalized regions of interest (GROI) provide a powerful syntax to perform operations on pixels that do not fall within a rectangular region in an image.

A number of functions can return generalized regions of interest, e.g., gtindex, ltindex, and eqindex, finite_index, nan_index, …. Once a generalized region of interest has been defined it can be used as an argument in array expressions.

Example 1.

The following statements will set all the pixels in an image X which fall within the values of 100 and 110 to 0.

```
zroi      = rindex(X,100,110);      // get list of pixels elements
X(zroi)   = 0;                      // set those elements to 0.
```

Example 2.

The following statements will compute the mean value of all those pixels in an image X which have an amplitude less than 0.5 the brightest pixel in X.

```
zroi      = ltindex(X,X.max * 0.5 );
result    = mean(X(zroi))                    // or   X(zroi).mean
```

GROIs allows for the manipulation of disjoint regions of interest in an image. In this method the pixel coordinates are stored as a complex row vector. The length of the vector corresponds to the number of pixels identified within the generalized region of interest. The real part of the row vector serves as a column index, while the complex part serves as a row index.

Program Flow Control and Relational Operators

The **if**, **if-else**, and **while** statements are used in MSHELL to alter the flow within a script file or to cause iteration. The range of each of these statements is a compound statement consisting of statements enclosed in brackets.

IF Statement

```
if( expression ){
        statements
}
if( expression ){
        statements
} else {
        statements
}
```

The **if** statement causes execution of its compound statements if and only if the relation in the expression results in a non zero value.

The **if-else** has two groups of compound statements. If the relation in the expression returns a non zero value , the first group of statements is executed otherwise the second group of statements is executed.

While Statement

```
while(expression){
        statements
        if(condition){
                wbreak
        }
        statements
}
```

The **while** statement causes repeated execution of its statements as long as the expression results in a non zero value. The relation is tested before each execution of its range and if the relations is false, control passes to the next statement beyond the range of the while statement.

The traditional '**for**' statement used in the C language, i.e.

```
for( expression1 ; relation ; expression2){
        statements
}
```

can be constructed using the **while** statement as:

```
expression1
while(relation){
        statements
        expression2
}
```

*An early exit from a while loop can be performed using the '**wbreak**' statement, similar to the C/C++ 'break' keyword. If more than one while loop are nested, 'wbreak' will only allow to exit the current while loop where the keyword is invoked. The following example will clarify this:*

```
i = 0
while ( i < 100 ) {
        print "outer loop no. "::int2str(i)::"\n"
        j = 0
        while ( j < 100 ) {
                print "inner loop no. "::int2str(j)::"\n"
                if ( j > 10 ) {
                        print "Exiting inner while loop...\n"
                        wbreak
                }
                j += 1
        }
        if ( i > 10 ) {
                print "Exiting outer while loop...\n"
                wbreak
        }
        i += 1
}
```

Control Expression with Numeric Values

The statements in an '**if**" or '**while**' block are executed depending on the value returned by the control expression. The control expression can include relational, equality, and logical expressions.

Always use parenthesis when using relational, logical, or equality operators. Do not assume a specific precedence.

Relational, logical, and equality operators all have the same precedence. Hence, parenthesis should be used to obtain the desired groupings. For example, in the following statement there is no ambiguity due to the use of parenthesis,

```
if( (i==4.8) && (p<3) ){
   x=y ;
}
```

Relational Operators

The expression syntax when using a **relational operator** is:

expression1 rel-op expression2

where the relational operators are:

<	less than
>	greater than
<=	less or equal to
>=	greater or equal to

Warning:
As clearly stated in Wikipedia when discussing floating point calculation: “The fact that floating-point numbers cannot faithfully mimic the real numbers, and that floating-point operations cannot faithfully mimic true arithmetic operations, leads to many surprising situations. This is related to the finite precision with which computers generally represent numbers.”
This can be seen in some occasions with relational operators, e.g.
a == a*b/b may not always return 1, even for finite values of b.

Equality Operators

The expression syntax when using an **equality operator** is:

expression1 equality-op expression2

where the equality operators are:

==	test for equality
!=	test for inequality

Logical Operators

The expression syntax when using a **logical operator** is:

expression1 logical-op expression2

where the logical operators are:

&&	logical and
||	logical or

Control Expression with Strings

The following are the valid comparisons that can be done with strings:

$s1==$s2
$s1!=$s2
$s1<$s2
$s1>$s2

Remember that these type of comparisons are only meaningful if used within the control expression in a '**while**' or '**if**' statement. For example, the following code performs a test on the string $a and displays itself as an image depending on the result of the test:

```
$a="hello"
if($a=="hello"){
    x = text2image($a);
    view x;
}
```

Look-Up-Table Manipulation

Look-up-tables are primarily used to map intensity values displayed on the screen. Output LUTs have 256 entries numbered 0 through 255 corresponding to the 256 possible different intensity values or colors.

Output LUTs

Before an image in memory is displayed on the screen, it goes through an output LUT. The image's pixel values are used as indices into the output look-up-table, the output of which is displayed on the screen. The default LUT is the graylevel one.

- Explicit attachement of an LUT - say 'x' is a image to be displayed and you want to attach a particular LUT, say myLUT, then the following can be done:

  x.defLUT = myLUT

The following example creates a LUT and assigned to a variable to provide intensities of red:

```
/* initialize LUT */
red = (0,255,1);
green = (0,255,1);
blue  = (0,255,1);
mycolut = red # 0*green # 0*blue;
x = hammiw(256,256)*255
x.LUTdef = mycolut
view x;
```

MSHELL Script Files (.msf,.msh,.vsh)

Script files provide a powerful tool to achieve repetitive processing tasks in a simple manner.

There are two types of script files in MSHELL, i.e. **FUNCTION** files and **INCLUDE** files.

Function Files (.msf or .mef)

A MSHELL function file, or external function, permits the user to define its own functions using the MSHELL language syntax. Local variables defined within a FUNCTION file are automatically erased by the MSHELL interpreter when the script file finishes execution.

Function file must be saved with the **'.msf'** extension. A function file can also be encrypted by using the MSHELL encryption commands (see **writetext_enc** command). In this case the extension must be **'.mef'**. This way MSHELL will descrypt the function file before calling the function content.

Syntax

A valid **MSHELL function must follow the following rules**:

- The instructions of a MSHELL function must be stored in a file with the same name as the function, e.g. if the function name was MYFUNC, then the file name must be MYFUNC.MSF.
- Only one function per file.
- Array and string variables can be used as input.
- A function can only return Array variables (at least one must be returned). Strings can be returned in the '.text' attribute of an array variable.
- If a variable is not defined at the present function level the interpreter **will not** look for it at the previous function level. The exception to this are system variables, M_, which are treated as global.
- The first eight characters in the file must be the string FUNCTION follow by the list of output arguments, equated to the function name, and followed by the list of input arguments.

The following is a simple MSHELL function file.

```
FUNCTION [out1,out2]=MYFUNC[in1,in2,in3,$in4]
/* This is a dummy function */

a = 10*in1;   b = 3*in2;
print "The string passed was "::$in4 ::"\n"
out1 = in1-in2
out2 = in1*.in2*.in3 - a + b
```

Notice that the variables 'a' and 'b' in the above example only exist during the duration of the subroutine.

Variables needed within the function must be passed to the function and new variables not implicitly declared in the calling statement will be automatically declared as **LOCAL** variables.

An actual call to the above example function could be,

```
x= hammiw(32,32)
y = gtclipto(x,0.5,0.5)
z = x-y
[res1, res2 ] = MYFUNC[ x,y,z]
```

where `res1` and `res2` will contain the result to the external function call.

It is possible to embed example code in a function to describe its usage better. The example code is contained between the delimiter

```
FUNTION …
/* This function .…

// EXAMPLE START
    X = 1; // first line of sample code …

// EXAMPLE END
*/

// actual function code follows…
```

The following block of code demonstrates this.

```
FUNCTION [out1,out2]=myfunc333[x,$str]
/*
// This is an example function.
// To test the behaviour of the interpreter when passing information
// into a function or making copies of arrays.
// EXAMPLE START
   $mystring = "hello world"
   x=hammiw(256,256)*255    // test image
   x.text="hola"    // initialize .text attribute

    [y,z]=myfunc333[x,$mystring]    // call the test function

   print " back from function call:  x(0,0)="::float2str(x(0,0))::"\n"
   print y.text::"\n"   // print text to screen
   view y           // view variable as image
   y(0,0)=255       // modify content of y ...
                    // this trigger a deep-copy of the values in x,
                    // follow by a modification of the values in y
   // To see update in screen user must trigger screen update,
   //  e.g. view y
   view y
   view z
   q=y
   print "q.text (right after the q=y assignment) ==>'"::q.text::"'\n"
   q(1,1)=0         // the element change triggers
                    // q to make its own deep copy of the array values
   print "q.text (right after q(1,1) was set to 0) ==>"::q.text::"\n"
                    // note that above … the text attribute is not
                    // copied in a deep copy
// EXAMPLE END
*/
 print "within fuction:  x.text = "::x.text::"  was received from the
caller\n"
out1 = x            // make a copy of x.

// In actuality the above is a copy-on-write allocation.
// MSHELL uses copy-on-write (COW) to save memory.
// The actual copy happens when one of the arrays is modified.
// For example, see the following block of code ...

x(0,0)=255          // mofify value of x(0,0) element within subroutine

// This will trigger a decoupling of the local x variable
// from the 'x' in the caller application, and
// from the local 'out' variable.

if( out1(0,0) != x(0,0) ){
   print "within function:  out(0,0) was not modified due to implicit
deep copy\n"
}
out1.text = $str ;  // save some text in the out.text attribute
out2= x+x;
```

Include Files (.msh or .meh)

Include files are simpler than MSHELL function files and are not constrained by the FUNCTION rules. The user may think of an include file as a sequence of commands that can be invoked with a simple include call.

Typically include files are saved to disk with the extension '.**msh**'. An include file can be encrypted by using the MSHELL encryption commands (see **writetext_enc** command). In this case the extension must be **'.meh'**. This way MSHELL will decrypt the file before executing it.

Include files do not erase local variables upon termination.

Virtual Include Files (.vsh)

A modification to the standard **'.msh'** is the **'.vsh'** extension; this allows MSHELL to automatically execute the entire contents of the script when opened using the **Image|Open** menu item or **'reada'** syntax of MSHELL. It is particularly used with 'Virtual' variables.

Importing and Exporting Data

Importing Data

Text or array data can be imported in a number of different ways and supporting a number of industry standard formats. Must of the support for loading array or image data is via the the internal 'reada()' function (see page 231). The following table provide a simple description of all basic loading functions.

Basic loading functions	**Brief Description**
readtext()	Use this function to load a text file into a memory. Note: It also has the nice ability to read files over HTTP.
readf()	This function is used to perform a formatted read of a scalar or a string from a file unit.
reada()	Reads an array or image from disk. Multiple file formats (or modes) are supported. Including a generic one that tries to figures the input data format.
V(),	MSHELL has a special variable, '**V**', called the virtual variable. With this variable the user can manipulate an image file which can be as large as 2^64 pixels! It supports many formats: 1bytes/pixel, floating point, double precision, unsigned integer, …
fits_...	Use this class of functions to load Flexible Image Tranfer System (FITS) formatted data. This format is used extensively in the Astronomy community. The reada() function can be then used to read particular data objects.
gdal_...	Use this class of functions to load raster data using the Open-Source Geographic Data Abstraction Library (GDAL). The MSHELL/GDAL interface provides extensive access to many geographic raster data formats, e.g. GEO-Tiff, CEOS, HDF, …. See discussion in Appendix.
ncread()	Use this function to load NetCDF type of data.
pds_...	Use this class of functions to load and manipulate Planetary Data System data headers. The reada() function can also be used to read some PDS data objects.

Exporting Data

MSHELL can write image or array data in a number of different output formats, see the writea() and reada() functions.

Data stored in the MSHELL's **char** and **float** format contains a simple 9 byte header. The first 4 bytes contain the number of rows (unsigned 32bits number), the next 4 bytes contain the number of columns (unsigned 32bits number), and the last byte contains a flag indicating if the data is real or complex (1=complex, 0=real).

Internal Functions

The user can locate a specific function by first looking into the Classes of MSHELL's Internal Functions where commands are divided into functional areas, **see Appendix B**.

Given a function name or symbol the user can locate specific information about its use under the alphabetical listing.

MSHELL array expressions can be used as arguments to other MSHELL functions. In most of the following functions the input to the functions are arrays and the output result is another array.

Math Error Handling and Indexing

In MSHELL floating point exceptions generate either results in the form of NOT-A-NUMBER (NAN), infinity (+INF), or minus infinity (-INF). The user must inspect an array for such an occurrence to determine if invalid number are present in the array.

The example below illustrates manipulations that result in NAN or +INF or -INF. The user can control how math related errors are reported using the system variable 'M_matherrflag' described under M_ in Appendix B.

```
[ready]: cos(1e38)
  -NAN
[ready]: 1/0
  +INF
[ready]: -1/0
  -INF
[ready]: 0/0
  -NAN
[ready]: x = 1/0 :: 0/0
[ready]: x(0,0)
  +INF
[ready]: x(0,1)
  -NAN
[ready]: log(0)
  -INF
[ready]: log(-1)
       0 + 3.14159i
[ready]: 0^0
  1
[ready]: y = 0::1::2:: (0/0)
[ready]: y
(10^0) X
row 0 =
      0.00       1.00       2.00       -NAN
[ready]: z = 0::1::2:: (1/0)
[ready]: z
(10^0) X
row 0 =
      0.00  1.00   2.00       +INF
[ready]: eqindex(y,1/0)
3 + 0i
```

The mshell index operators can be useful at locating and tracking array elements with valid or not valid numeric values, e.g.

```
nan_index()     //ONLY way to identify NaN elements
finite_index()
not_finite_index()
ltindex()
leindex()
eqindex()
neqindex()
gtindex()
geindex()
rindex()
rindexc()
```

The following instructions can illustrate how to use index type of functions to locate elements in an array that are NaN or finite.

```
z=0                     // zero value
show z
minf = -1/0         // - infinity
show minf
nan = -1/0+1/0      // generates a Not a Number
show nan
uno = 1
show uno

v = z::minf::nan::uno   // construct a vector
v

print "index(v)         // index non-zero elements\n"
index(v)

print "\n finite_index(v)   // index finite elements\n"
finite_index(v)

print "\n eqindex(v,z)  //index elements equal to 0 \n"
eqindex(v,z)

print "\n eqindex(v,minf)   //index to elements equal to -infinity \n"
eqindex(v,minf)

print "\n eqindex(v,nan)    //index to elements equal to NaN \n"
eqindex(v,nan)

print "\n nan_index(v)  // index to Not-a-Number elements\n"
nan_index(v)

print "\n ltindex(v,uno)    // index to elements less than one\n"
ltindex(v,uno)

print "\n rindex(v,-1/0,1000)   // index to all elements between minus
infinity
                        //  and 1000\n"
rindex(v,-1/0,1000)

print "\n geindex(v,1)  // index to all elements >=1 \n"
geindex(v,1)
```

Extendibility of the Environment

In addition to the internal functions included and listed above you can further extend the capabilities of MSHELL by:

- Accessing system based stand alone executables, giving you access to your other executables in the computer, e.g. commercial-off-the-shelf programs, other users executables, or system executables.
- Accessing other applications that support Dynamic Data Exchange.
- Accessing your own 'C' functions as Dynamic Link Libraries.

System level access

MSHELL permits the users to trigger the execution of stand alone programs via the **system( )** command, and the a class of functions that start with sys_..., e.g. sys_copy(…). The use of these functions is discussed in page 298.

Dynamic Data Exchange (only for MS-Windows Support)

In the MS-Window environment, MSHELL is capable of communicating with other applications that support dynamic data exchange (DDE). The following MSHELL commands are used to establish communications links with other applications via DDE.

DDEInit - this command is used to start a conversation on a particular topic with the server application. Syntax: chan = DDEInit("Application Name","Topic"). "Application Name" is the name of the application you want to communicate with (Ex. MSAccess), and "Topic" is the name of the particular topic. This command returns a channel number associated with the conversation you are requesting or -1 if the operation fails.

DDETerm - this command terminates a conversation. Syntax: DDETerm(chan). chan is the number returned by DDEInit.

DDEExec - this command is used to send a command to the server application once the DDE conversation is established. Syntax: DDEExec(chan,cmd). chan is the channel number returned by DDEInit, and cmd is a string you want the server to execute. DDEExec will return 0 if the server accepted the command, 1 otherwise.

DDEPoke - this command is used to request the server application to accept an unsolicited data item value. Syntax: DDEPoke(chan,item,val). chan is the channel number returned by DDEInit, item is a string that identifies the data item you wish to send a value for, and val is a string containing the value. DDEpoke will return 0 if the server accepted the data item value, 1 otherwise.

DDEReqS - this command is used to request the server application to provide the value of a data item. Syntax: $var = DDEReqS(chan,$item). $var is a MSHELL string variable, chan is the channel number returned by DDEInit, and item is a string that identifies the data item you are requesting the value of.

DDEReqV - this command is used to request the server application to provide the value of a data item. Syntax: var = DDEReqV(chan,$item). 'var' is a MSHELL array variable, chan is the channel number returned by DDEInit, and item is a string that identifies the data item you are requesting the value of.

Example: Using MSHELL scripting language

```
$path = "M:\\NEWINDEX\\BYACCESS\\"
$database = "CL_0001"

/* Open Database */
chan1 = DDEInit("MSAccess","System")
$command = "[OpenDatabase "::$path::$database::".MDB]"
$command
DDEExec(chan1,$command)
DDETerm(chan1)

/* Query Database */
$topic = $database::";SQL"
chan1 = DDEInit("MSAccess",$topic);
$temp = "SELECT NEW_IMAGENAME";
status= DDEPoke(chan1,"SQLText",$temp);
$temp = " FROM header";
status=DDEPoke(chan1,"SQLText",$temp);
$temp = " WHERE ("
status=DDEPoke(chan1,"SQLText",$temp);
$temp = "([SENSOR_NAME]=\"UVVIS\")
status=DDEPoke(chan1,"SQLText",$temp);
$temp = " AND ([FILTER]=\"B\") AND ([MISSION_PHASE]=\"LUNAR AND
MAPPING\")"
status=DDEPoke(chan1,"SQLText",$temp);
$temp = " AND (([CENTER_LATITUDE]>=14.0) AND
([CENTER_LATITUDE]<=35.0))"
status=DDEPoke(chan1,"SQLText",$temp);
$temp = " AND (([CENTER_LONGITUDE]>=25.0) AND
([CENTER_LONGITUDE]<=30.0))"
status=DDEPoke(chan1,"SQLText",$temp);
$temp = ");"
status=DDEPoke(chan1,"SQLText",$temp);
$res = DDEReqS(chan1,"Data");
if ( strlen($res) > 0 ) {
   $query = $query::"\n"::$res
 }
DDETerm(chan1);
```

Dynamic Link Libraries (DLL) [only under MS-Windows Support]

In the MS-Windows environment MSHELL permits the users to provide their own functions via dynamic link libraries. Following are the steps required to make use of this capability.

First, write a C program containing the code you want to execute. Include user.h in the header section; user.h is included as part of the installation. The functions that can be called from MSHELL must conform to the following declaration: ARRAY *fname(ARRAY *, ARRAY *, ARRAY *, ARRAY *, ARRAY *), where ARRAY is a data structure defined in user.h. Note that the declaration requires five ARRAY* inputs but the user need not use the five inputs. The functions the user wants to call from MSHELL must be exportable.

Second, generate a 32-bit dynamic link library. The C compiler/linker you use must be able to generate a 32-bit DLL. Consult your compiler reference manual.

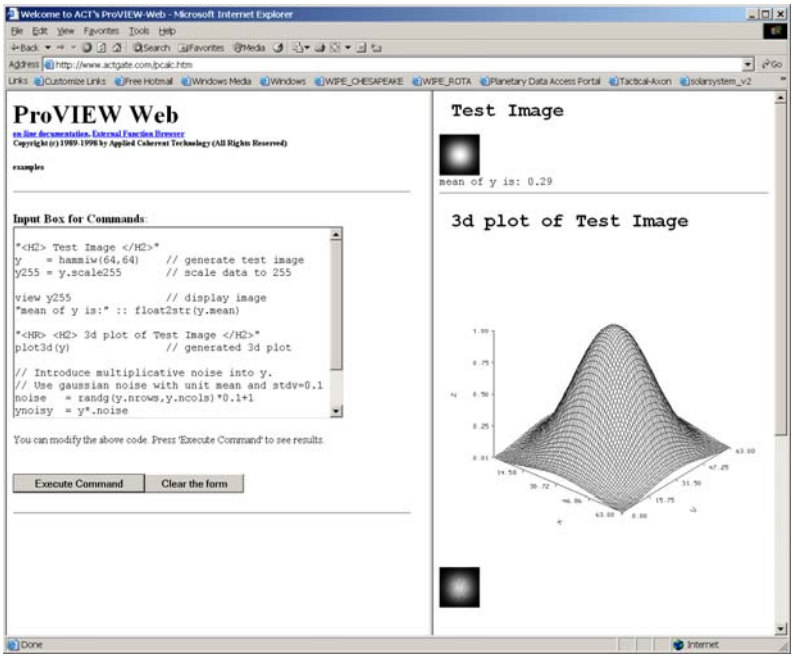
Note: The memory allocation routines that MSHELL uses are contained in mem.dll. If you plan to use memory allocation routines in your code (i.e., malloc, calloc, realloc, free, strdup) it is strongly recommended that you use instead the functions contained in mem.dll (i.e., NewMalloc, NewCalloc, NewRealloc, NewFree, NewStrdup). The file prvmem.h is provided with the MSHELL installation. Include it in your source code if you are going to make use of the mem.dll memory allocation routines. If you are using Microsoft Visual C++, include the import library memvc.lib in your project. If you are using Borland C/C++, include the import library membc.lib in your project. Both memvc.lib and membc.lib are included as part of the MSHELL installation.

From within MSHELL's Command Shell Window register the DLL using the following command: loadDLL($fullpath\\$dllname), where $fullpath is the path to the DLL including drive letter, and $dllname is the name of the DLL. Note that loadDLL will return 0 if the DLL is successfully loaded and 1 otherwise.

Call the function in the DLL using the following MSHELL command: callDLL("$dllname","$functionname",arg1,arg2,arg3,arg4,arg5). "$functionname" is the name of the function in the DLL you want to call; arg1, arg2, arg3, arg4 and arg5 are the arguments you want to pass to the function.

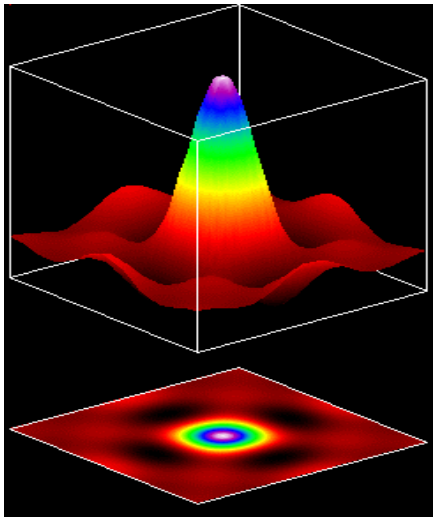
```
Example of User Provided Functions as Dynamic Link Libraries

#include <stdio.h>
#include "user.h"

#ifdef __BORLANDC__
ARRAY* _export test(ARRAY *a1, ARRAY *a2, ARRAY *a3, ARRAY *a4, ARRAY
*a5);
#endif

#ifdef _MSC_VER
__declspec( dllexport ) ARRAY* test(ARRAY *a1, ARRAY *a2, ARRAY *a3,
ARRAY *a4, ARRAY *a5);
#endif

/*********************************************************************/
--- Include the following two functions in your code. MSHELL will call
--- SetInitA and SetFree upon loading the DLL to pass the addresses of
--- the functions inside MSHELL that InitA and Free will call. It is  -
-- very important that you initialize variables of type ARRAY* using  -
-- InitA. You must pass to InitA a name you want to assign to
--- the variable, the number of rows, the number of columns, and the
--- type (0-real, 1-complex).
*********************************************************************/

void SetInitA(void *fn)
{
_InitA = (ARRAY* (*)(char *ptr, unsigned long sizej, unsigned long
                        sizei, unsigned char type))fn;
}
void SetFree(void *fn)
{
_Free = (void (*)(ARRAY *a))fn;
}
/*********************************************************************/

ARRAY* test(ARRAY *a1, ARRAY *a2, ARRAY *a3, ARRAY *a4, ARRAY *a5)
{
UN32 i, j;
ARRAY *c;

c = InitA("test",a1->sizej,a1->sizei,0);
if( c )
{
  for(i=0; i<a1->sizej; i++){
     for(j=0; j<a1->sizei; j++){
                    c->re[i][j] = a1->re[i][j] + 10.0;
     }
  }
}

return c;
}
```

For illustration a web version of the MSHELL engine can be accessed at: **http://www.actgate.com/pcalc.htm** MSHELL commands can be typed on the left hand side and executed on the server side.


Welcome to ACT's ProVIEW-Web - Microsoft Internet Explorer
ProVIEW Web
Input Box for Commands:
"<H2> Test Image </H2>"
y = hammiw(64,64) // generate test image
y255 = y.scale255 // scale data to 255
view y255 // display image
"mean of y is:" :: float2str(y.mean)
"<HR> <H2> 3d plot of Test Image </H2>"
plot3d(y) // generated 3d plot
// Introduce multiplicative noise into y.
// Use gaussian noise with unit mean and stdv=0.1
noise = randg(y.nrows,y.ncols)*0.1+1
ynoisy = y*.noise
You can modify the above code. Press 'Execute Command' to see results.
Execute Command
Clear the form
Test Image
mean of y is: 0.29
3d plot of Test Image

Note: The file keywords.txt located on the same main directory where MSHELL is residing can be used to specify all commands that remote users are not allowed to execute. This is used as safety measurement.

Appendix A: MSHELL SCRIPTS - External Functions Tree



Introduction

With over 140 internal functions and **over 100 external functions (scripts)**, MSHELL is a powerful and flexible environment in which to perform signal and image processing operations.

The ACT-REACT installation contains a scripts directory that is broken in subdirectories by functional categories. The user is strongly encouraged to explore this directory and all its embedded demot code functions for gaining a better understanding of the MSHELL scripting language. All these functions and their embedded demo code can be tested directly from the ACT-REACT Analysis panel shown below

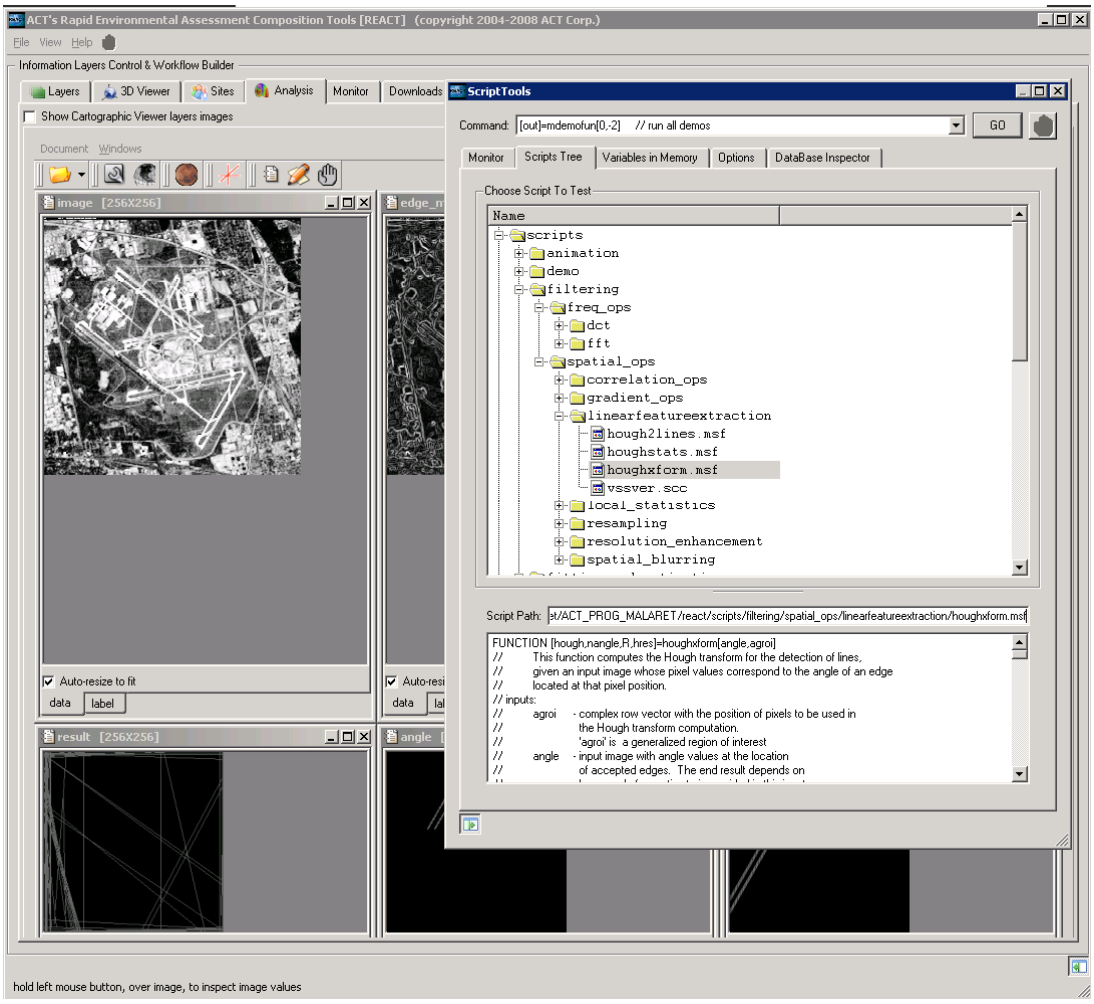
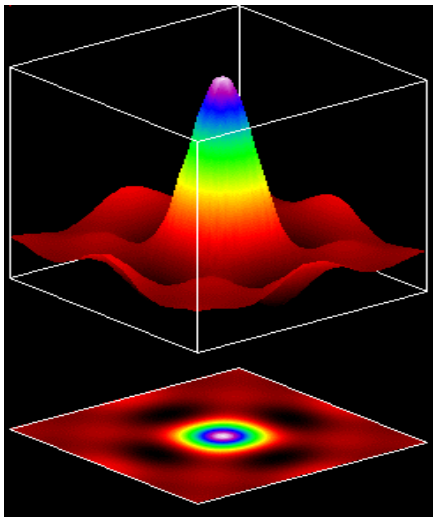


Figure 5 Sample Screen showing the Scripts Demo Tree.

Appendix B: Internal Functions



(by Category and Alphabetical Listing)

Internal Functions - Alphabetical List

Much of ACT-REACT power resides in the MSHELL Interpreter. With a continusly growing number of internal commands, ACT-REACT has a flexible structure that readily permits tailoring to specific applications through User Defined external functions and script files. A complete list, **by category**, of the internal functions is available after the Table of Contents in the firt few pages of this document.

This appendix is an alphabetical listing with descriptions and examples of all the current **ACT-REACT&MSHELLInternal Functions**.

- Symbols -

(a,b,s[,n]) Generate a 1-D or 2-D ramp

Syntax: **(**start_value**,** end_value**,** step_size**)** 1-D
(start_value**,** end_value**,** step_size**,** number_of_rows**)** 2-D

Description: returns a 1-D or 2-D ramp of values

Example: The following applications illustrate the use of the 1-D and 2-D ramp function.

```
[ready]: (0,3,1)            //generate a 1-D row
  0.00   1.00   2.00   3.00
[ready]: (0,1,0.2)          // generate 1-D row with fractional step
size
  0.00   0.20   0.40   0.60   0.80
[ready]: (3,0,1,2)          // generate a 2-D matrix
  3.00   2.00   1.00   0.00
  3.00   2.00   1.00   0.00
[ready]: pi = 3.14159;      // define PI
[ready]: plot( 2 + cos( (0,4*pi, pi/4) ) )  // create a plot
```

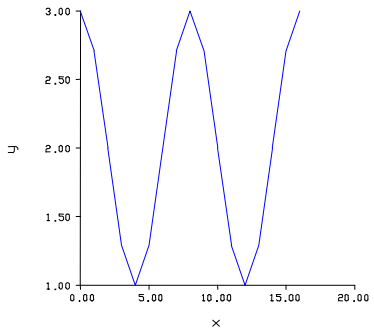


Figure 1

+ *Array Addition*

Syntax: a **+** b

Description: The operator symbol **+** is used to perform the addition of two array expressions. The actual sum is implemented as:

$$c_{j,i} = a_{j,i} + b_{j,i} \quad \text{,for all j, i;}$$

where j and i are, respectively, row and column indices. If 'b' is a scalar and 'a' is not, then 'b' will be added to each of the elements in 'a'.

Example: The following MSHELL statements illustrate simple examples of array addition,

```
[ready]: a = (10,15,1)  // creates row vector 'a'
[ready]: b = a          // copies 'a' into 'b'
[ready]: c = a+b        // add corresponding elements in 'a' and 'b'
[ready]: c              // prints the 'c' row vector
(10^0) X
row 0 =
 20.00  22.00  24.00  26.00  28.00  30.00
[ready]: c+5            // add 5 to every element in 'c'
(10^0) X
row 0 =
 25.00  27.00  29.00  31.00  33.00  35.00
```

- *Array Subtraction*

Syntax: a **-** b

Description: The operator symbol **-** is used to perform the subtraction of two array expressions. The actual subtraction is implemented as:

$$c_{j,i} = a_{j,i} - b_{j,i} \quad \text{,for all j, i;}$$

where j and i are row and column indices respectively. If 'b' is a scalar and 'a' is not, then 'b' will be subtracted from all the elements in 'a'.

Example: The following MSHELL statement will subtract array 'b' from 'a' and store the result in 'c'.

```
[ready]: c = a-b
```

* *Matrix Multiplication*

Syntax: a * b

Description: The operator symbol * is used to perform the multiplication of two matrices or arrays. The multiplication follows the rules of matrix multiplication used in linear algebra:

$$c_{j,i} = \sum_n a_{j,n} \cdot b_{n,j} \quad \text{,for all j, i;}$$

where j and i are row and column indices respectively. An error message will be generated if the number of columns in 'a' is not equal to the number of rows in 'b'. If 'a' is a scalar and 'b' is not (or vice versa), every element in 'b' will be multiplied by 'a'.

Example: The following MSHELL statements illustrate simple examples of array multiplication,

```
[ready]: a = ones(3,3)      // creates 3 x 3 matrix with all ones
[ready]: b = ones(1,3)      // creates 1 x 3 vector with all ones
[ready]: a                  // prints 'a'
row 0 =
  1.00   1.00   1.00
row 1 =
  1.00   1.00   1.00
row 2 =
  1.00   1.00   1.00
[ready]: b                  // prints 'b'
row 0 =
  1.00   1.00   1.00
[ready]: b*a                // multiply row vector 'b' by matrix 'a'
(10^0) X
row 0 =
  3.00   3.00   3.00
 [ready]: a*b                   // an invalid multiplication
>>>error = 4 ---incompatible dimensions
[ready]: b*4                    // multiply each element of 'b' by 4
row 0 =
  4.00   4.00   4.00
```

*. *Array Element Multiplication*

Syntax: a *. b

Description: The operator symbol *. is used to perform the multiplication of corresponding elements between two arrays. The multiplication is implemented as:

$$c_{j,i} = a_{j,i} \cdot b_{j,i} \quad \text{,for all j, i;}$$

where j and i are row and column indices respectively. An error message will be generated if 'a' and 'b' do not have the same dimensions.

Example: The following MSHELL statement will multiply corresponding elements in array 'a' and 'b', and store the result in 'c',

```
[ready]: a = 1::2::3        // creates a row vector
[ready]: a                  // print array
row 0 =
  1.00   2.00   3.00
[ready]: b = a
[ready]: c = a*.b           // mult. corresponding elements
[ready]: c                  // print results
row 0 =
  1.00   4.00   9.00
```

\\ *Continuation Line delimiter*

Description: The symbol **** tells the MSHELL interpreter that the present statement will be continued on the next physical line. Continuation lines can only be used within MSHELL script files (***.msf** or ***.msh**)

Example: The following 2 lines of code illustrate the use of the continuation line delimiter within a script function. The result of the expression is 21.

```
x = 4*5 + \\
1
```

// *Single Line Comment Delimiter*

Description: The symbol **//** is used to specify that a single line comments will follow. All characters that follow this symbol within a given physical line, will be ignored.

Example: The following illustrates the use of the single line delimiter.

```
[ready]: pi = 4*atan(1.)    // this text will be ignored
```

/ *Array Division by Scalar*

Syntax: a **/** b

Description: The operator symbol **/** is used to perform the division of each element of an array by a scalar. An error message will be generated if 'b' is not a scalar, i.e. a 1x1 array. The actual division is implemented as:

$c_{j,i} = a_{j,i} / b$ for all j, i;

where j and i are row and column indices respectively.

/. *Element Array Division*

Syntax: a **/.** b

Description: The operator symbol **/.** is used to perform the division of corresponding elements between two arrays. An error message will be generated if 'a' and 'b' do not have the same dimensions. The actual division is implemented as:

$$c_{j,i} = a_{j,i} / b_{j,i} \quad \text{for all j, i;}$$

where j and i are row and column indices respectively.

Example: The following MSHELL statement will divide the elements in array 'a' by the elements in array 'b', and attempt to divide elements in array 'a' by a scalar.

```
[ready]: a = 1::3::5        // generates a row vector
[ready]: b = a
[ready]: a/.b                   // divide corresponding elements
row 0 =
  1.00   1.00   1.00
[ready]: a/.4                   // since 'x' is not 1x1 an error occurs
>>>error = 4 ---incompatible dimensions
```

^ *Raise Array Elements to a Power*

Syntax: a **^** b

Description: The operator symbol **^** or caret is used to raise the elements of an array to a given constant power, or the power specified by the corresponding elements of another array. The above statement will raise the elements in array 'a' to the power specified by the elements in array 'b', where 'a' and 'b' have the same dimensions. For 'a' and 'b' input arrays, we have the following:

If 'a' and 'b' have the same dimension, the actual operation is implemented as:

$$c_{j,i} = a_{j,i}^{b_{j,i}} \quad \text{for all j, i;}$$

If 'b' is a scalar (i.e. a 1 x 1 array) and 'a' is not, the operation is implemented as,

$$c_{j,i} = a_{j,i}^{b_{0,0}} \quad \text{for all j, i;}$$

If 'a' is a scalar (i.e. a 1x1 array) and 'b' is not, the operation is implemented as,

$c_{j,i} = a_{0,0}^{b_{j,i}}$ for all j, i;

where j and i are row and column indices respectively. Note that in each case the result 'c' is an array; only in the case of both 'a' and 'b' scalars, will 'c' be a scalar.

Example:

```
[ready]: x = (1::3)#(4::5)  // creates a 2 by 2 matrix
[ready]: x                          // print 'x'
row 0 =
  1.00   3.00
row 1 =
  4.00   5.00
[ready]: 2^x                  // raise 2 to 'x'
row 0 =
  2.00   8.00
row 1 =
 16.00  32.00
[ready]: x^0.5                // raises 'x' to 0.5
row 0 =
  1.00   1.73
row 1 =
  2.00   2.24
[ready]: x^x                  // raises corresponding elements
row 0 =
  1.00  27.00
row 1 =
256.00 ###.##
[ready]: M_format = "00000.00"
[ready]: x^x
row 0 =
    1.00    27.00
row 1 =
  256.00  3125.00
```

' *Matrix Transpose*

Syntax: a'

Description: The operator symbol ' is used to generate the transpose of an array. Mathematically, this operation is implemented as:

$c_{row=i,col=j} = a_{row=j,col=i}$ for all j, i;

where j and i are row and column indices respectively in 'a'.

Example: These MSHELL statements assigns the transpose of 'a' to 'c'.

```
[ready]: data = randg(3,3)  // generate a 3x3 random array
[ready]: data                  // print 'data'
row 0 =
   -0.18     0.10     1.36
row 1 =
    0.61     0.57     1.23
row 2 =
   -1.10     1.55    -0.58
[ready]: data'                 //  transpose of 'data'
row 0 =
   -0.18     0.61    -1.10
row 1 =
    0.10     0.57     1.55
row 2 =
    1.36     1.23    -0.58
```

:: *Concatenate Arrays or Strings*

Syntax: a **::** b

Description: Given two arrays with the same number of rows, this operation will append the corresponding rows of one array to the other array. Likewise, given two strings (which can be considered one row arrays or row vectors) this operation will append the two strings.

Example: For the arrays 'a' and 'b', the following MSHELL statement will append the rows of 'a' to the rows of 'b', and store the result in 'c'.

```
[ready]: c = a::b
```

The number of columns in 'c' is equal the sum of the number of columns in 'a' and 'b'. The following MSHELL commands will assign to the variable 'y' the concatenation of two arrays.

```
[ready]: x = 1::2           // creates a row vector
[ready]: y = x::x       // concatenates 2 vectors
[ready]: x
row 0 =
   1.00   2.00
[ready]: y
row 0 =
   1.00   2.00   1.00   2.00
```

The following MSHELL commands will assign to the string variable '$str1' the concatenation of two strings.

```
[ready]: $str = "SSS"       // creates a string
[ready]: $str1 = $str::" last name" //concatenates another string
[ready]: $str1
SSS last name
```

Column Augmentation

Syntax: a # b

Description: Given two arrays with the same number of columns, this operation will append the corresponding columns of one array to the other array.

Example: The following MSHELL statement will append the columns of 'b' to the columns of 'a', and store the result in 'c'.

```
[ready]: c = a#b
```

The number of rows in 'c' equals the sum of the number of rows in 'a' and 'b'. The following MSHELL commands illustrate the above,

```
[ready]: a = (0,3,1)'        // creates a column vector
[ready]: b = ones(2,1)       // creates a 2-d identity column vector
[ready]: c = a#b             // augments a with b and assigns result to c
```

= *Assignment*

Syntax: c = a

Description: This operator symbol, **=** , is used to assign the output of an MSHELL expression to a variable. MSHELL will not allow you to assign an array expression to an already defined string variable, or vice versa.

Example: The following MSHELL statement will assign the sum of two constants to the newly defined variable 'c'.

```
[ready]: c = 4 + sqrt(3.333)
```

If the variable 'c' has already been defined its content will be changed, otherwise it will be created.

: *Array Interval Delimiter*

Syntax: x(**:** ,n)

Description: Used to denote an interval of rows or columns.

Example: The following illustrates the use of the array interval delimiter:

To extract column number 3 of an array 'x', type:

```
[ready]: x(:,3);
```

To extract row number 2 in 'x' and assign it to 'y', type:

```
[ready]: y = x(2,:);
```

To extract the sub array in ‘x’ defined by rows 3 to 5 and columns 2 to 10, and copy to ‘y’ type:

```
[ready]: y= x( 3:5 , 2:10 )
```

To insert the array ‘y’ into the array ‘x’ starting at row 8 and column 0 type:

```
[ready]: x( 8: , 0: ) = y
```

To extract an image block starting at row 9 and column 20 type

```
[ready]: x(9:, 20: )
```

.m_ Intrinsic Array Attributes: x.m_LUTdef , x.m_voltype, ...

Intrinsic Attributes Associated with Array Variables

There are many intrinsic attributes associated with array variables. For example, these attributes can control the way a variable is displayed, and interpolated. Most of these attributes can be inspected and changed by the user. The following presents all the intrinsic attributes associated with array variables and their associated syntax. Controlling these attributes can give you finer control.

You may not need to use them since default values are normally applied. But for completeness, **let us denote 'x' as an existing array variable**. Then:

Display Control of an Array Variable

The following attributes support the control of how a varialbe is displayed.

x.m_viewflag Controls if an image is visible for display or not by setting:

x.m_viewFlag=1 forces the image to be displayed.

x.m_viewFlag=0 disables the display of the image.

Note that the default value for this attribute is zero, not to display the variable.

x.m_viewheight Controls the height of the display window. NOT SUPPORTED IN ACT-REACT

x.m_viewwidth Controls the width of the display window. NOT SUPPORTED IN ACT-REACT

x.m_viewhscrollpos Controls the horizontal scroll position of the display window. NOT SUPPORTED IN ACT-REACT

x.m_viewvscrollpos Controls the vertical scroll position of the display window.
NOT SUPPORTED IN ACT-REACT

x.m_viewx0 Controls the horizontal position of the upper left corner on the display.
NOT SUPPORTED IN ACT-REACT

x.m_viewy0 Controls the vertical position of the upper left corner on the display.
NOT SUPPORTED IN ACT-REACT

x.m_viewlut Contains the active look-up-table to be used for '**x**'.
NOT SUPPORTED IN ACT-REACT only in the CGI version of MSHELL.

x.m_viewmaxval Controls the maximum value to be displayed on the screen.

x.m_viewminval Controls the minimum value to be displayed on the screen.

x.m_maxminflag If set to 1 then the image is displayed using the .m_viewminval and .m_viewmaxval as the minimum and maximum value to display.

x.text Allows you to access (either read or set) the text attribute of the image.

Image variables may contain associated text, which can be accessed by adding '.text' to the variable name. For exaple,

```
x=4;
x.text=”my number”
print x.text ::”\n”
```

x.vroi Extracts the coordinates of the variable region of interest.

Every image variable has associated with it a rectangular region of interest. When a variable is created this region of interest is set to be the whole image. The coordinates of the defined region of interest can be easily accessed at the command line by appending '.vroi' to the image name. For example, the following line of code extracts the coordinates that define the variable region of interest (vroi) of an already defined variable, say X, and assigns it to a user defined variable called 'regionc',

```
[ready]: regionc = X.vroi
```

The notation X.vroi can be viewed as if vroi is an attribute of X.

x.aoi allows access to the actual pixel values defined by the region of interest associated with an array.

Given an array variable, say X, the actual pixel values can be easily accessed in the command line by appending '.aoi' to the image name. For example,

[ready]: subimage = X.aoi

extracts the subimage defined by X.vroi and assigns it to a user defined variable called 'subimage'. This could also be done using the following notation

[ready]: subimage = X(X.vroi)

MSHELL provides different ways to operate over regions of interest. For example, to add 10 to all pixels falling within the defined region of interest, and updating the display type

[ready]: X(X.vroi) = X.aoi + 10

[ready]: view X

This could also be done as follows,

[ready]: regionc = X.vroi

[ready]: X(regionc) = X(regionc)+10

[ready]: view X

x.LUTdef allows to assign/read LUTs to an array variable. See LUTdef system variable for additional info.

x.mapinfo holds the map info string associated to a georeferenced image

x.m_type holds the type (real or complex) of the array variable.
=0 → real
=1 → complex
(this is a read-only attribute)

Image Mensuration Control of an Array Variable

The following set of image attributes are related to image mensuration. They all start with '.m_' just as the above intrinsic attribute commands did.

x.m_x0 user defined horizontal position of upper left pixel in image

x.m_dx user defined spacing between two adjacent horizontal pixels as you move from left to right**x.m_y0** user defined vertical position of upper left pixel in image

x.m_dy	user defined spacing between two adjacent pixels in the same column as you move from top to bottom
x.m_xunit	string describing the units of x.m_x0
x.m_yunit	string describing the units of x.m_y0

Volumetric Access of an Array Variable

The following attributes are related to the use of alternative volumetric representation of the data loaded in memory.

x.m_voltype	describes the alternative volume type representation to be used for visualization. This variable is read only. Its value can only be modified by the function **`alternateRGB`**( ) and **`alternateBSQ`**( ). voltype=0 ➔ normal 2d array representation voltype=1 ➔ band sequential representation voltype=3 ➔ RGB band sequential
x.m_nrows3d	when the x.m_voltype!=0, this call will return the effective number of rows in the volumetric cube
x.m_ncols3d	when the x.m_voltype!=0, this call will return the effective number of columns in the volumetric cube
x.m_nbands3d	when the x.m_voltype!=0, this call will return the effective number of bands in the volumetric cube
x.m_viewband	this index indicates which band to display when using the **view** command.

Once the **`alternateRGB`** or **`alternateBSQ`** representation are enabled, the user can access, a rectangular region of interest, roi, using the following notation,

x(roi| iband)

where,

- iband is a non-negative integer value giving the desired band number, starting at zero.
- roi is a valid rectangular region of interest within a single band.
- This construct can be used for reading only. To assign content to a whole plane, the notation x(: | band) = data, can be used. This is discussed below.

x(: | iband)

where, provides a short notation to select the whole band, i.e.

- The ':' delimiter is used in this particular example to denote the whole set of rows and columns in the selected image plane.
- iband is a non-negative integer value giving the desired band number, starting at zero.
- This construct can be used for reading and assignments.

See example code in alternateBSQ( ).

$string String Access Control

Syntax: **$*string*(rs:re,cs:ce) or $string(cs :ce) or …**

Description: The notation for accessing the content of a string variable is discussed in page 25, the string variable section.

Logical Relational Operators

<	Less Than Operator
>	Greater Than Operator
<=	Less Than or Equal To Operator
>=	Greater Than or Equal To Operator
==	Equivalent To Operator
!=	Inequivalent To Operator
&&	Logical AND Operator
||	Logical OR Operator

Syntax: *expression1* **OPERATOR** *expression2*

Description: These operators are used to perform logical checks on certain desired expressions.

Example: Notice the use of separating parenthesis to establish precedence in the example below:

```
if ( (I==4.8)  &&  (P>3) ){
                        x=y;
}
```

- A -

ab_plus_c *a * b + c*

Syntax: **ab_plus_c**(a, b, c)

Description: Returns the result of the computation *a * b + c*, performed in one go. *a* can be a real or a complex ARRAY of any dimension, while *b* and *c* must be real scalars.

abs *Absolute Value*

Syntax: **abs**(a) or a.**abs**

Description: Returns the absolute value of each element in the array.

Example: The following MSHELL statement will compute the absolute values for each element of 'a'.

```
[ready]: a=1::-2::3::-4 // stores these values on variable a
[ready]: abs(a)
row 0 =
   1.00    2.00    3.00   4.00
```

acos *Inverse Cosine*

Syntax: **acos**(a) or a.**acosor**

Description: Returns the inverse cosine of each array element. The output is in radians. The actual mathematical expression computed is given by,

$c_{j,i} = \text{acos}(a_{j,i})$ for all j, i;

where j and i are row and column indices respectively.

Example: The following MSHELL statement will compute the inverse cosine of 'a', and store the result in 'c'.

[ready]: c = acos(a)

addmenuitem Adds a User Defined Menu Item [TBD in ACT-REACT]

Syntax: **addmenuitem** "myscript.msh"

Description: Use this command to add the capability of invoking user defined script files from within the graphical user interface, where "myscript.msh" is a valid script file.

Example: The following line will add the 'mdemo.msh' file to the menu item list under User

[ready]: addmenuitem "mdemo.msh"

all_local all_local

Description: keyword used by 'save' function. See 'save' for details.

allstr allstr

Description: keyword used by 'save' function. See 'save' for details.

all Allows for "all" Variables to be included

Syntax: **all** (used in functions like 'free' and 'save')

Description: Use this command to access all variables at one time. It can be used with show all, to free all variables, or with free all, to free all variables.

Example: The following line will free all variables from memory

[ready]: free all

allocate_array Allocate an array and set its values

Syntax: allocate_array(nrows, ncols, value)

Description: Allocate a new ARRAY variable with the specified dimension and set all its elements to the specified value.

Example:

```
[ready]: x = allocate_array(10, 10, 0)  // same as "x = zeros(10, 10)"
[ready]: x = allocate_array(10, 10, 1)  // same as "x = ones(10, 10)"
```

See also: ones, zeros

---

alternate_bands_clear *reset array volumetric representation*

Syntax: alternate_bands_clear(x)

Description: Use this command to reset the array volumetric representation to normal 2d representation. In essence this commands undos array volumetric representation changes made through alternateRGB() or alternateBSQ.

See also: alternateRGB, alternateBSQ

---

alternateRGB *describe array as an RGB volume*

Syntax: alternateRGB(x)

Description: Use this command to let MSHELL know that when accessing the user specified variable, say 'x', to use an alternate volumetric representation. In essence this commands sets the internal variable attributes 'x.m_m_=3' and 'x.m_voldim' to match a band sequential RGB representation. Once the 'alternateRGB()' command is executed any view command will make use of the alternate representation. To read the voldim information use: x.m_nrows3d, x.ncols3d, and x.m_nband3d.

Example: see alternateBSQ( ) example.

---

alternateBSQ *describe array as a BSQ volume*

Syntax: alternateBSQ(x,Nrows,Ncols,Nbands)

Description: Use this command to let MSHELL know that when accessing the user specified variable, say 'x', to use an alternate volumetric representation. In essence this commands sets the internal variable attributes 'x.m_voltype=1' , i.e. a band sequential (BSQ) representation. It also sets the

'x.m_voldim' to
x.m_voldim=Nrows,Ncols,Nbands. If the user provided alternate representation is not possible it will return an error message.
Once the 'alternateBSQ()' command is executed any view command will make use of the alternate representation. To read the voldim information use: x.m_nrows3d, x.m_ncols3d, and x.m_nband3d.

Example: See attached figure and sample code.

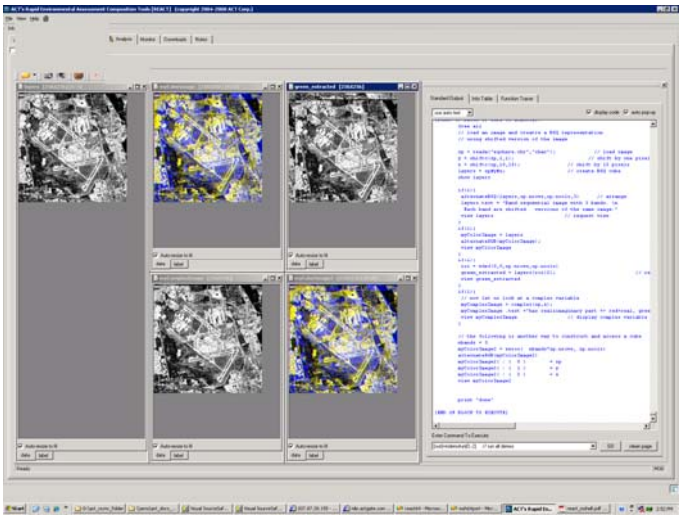


Figure 6 Creation and manipulation of a data cube using alternateRGB() and alternateBSQ().

```
free all
// load an image and creatre a BSQ representation
// using shifted version of the image

xp = reada("eqohare.chr","char");       // load image
y = shiftc(xp,1,1);             // shift by one pixel
z = shiftc(xp,15,15);           // shift by 15 pixels
layers = xp#y#z;            // create BSQ cube
show layers

if(1){
 alternateBSQ(layers,xp.nrows,xp.ncols,3)   // arrange
 layers.text = "Band sequential image with 3 bands. \n
  Each band are shifted   versions of the same image."
 view layers                    // request view
}
if(1){
 myColorImage = layers
 alternateRGB(myColorImage);
 view myColorImage
}
if(1){
 roi = wdef(0,0,xp.nrows,xp.ncols)
 green_extracted = layers(roi|2);              // read a band
 view green_extracted
}
if(1){
 // now let us look at a complex variable
 myComplexImage = complex(xp,z);
 myComplexImage .text ="has real&imaginary part => red=real,
green=imaginary"
 view myComplexImage            // display complex variable
}

// the following is another way to construct and access a cube
nbands = 3
myColorImage2 = zeros(  nbands*xp.nrows, xp.ncols)
alternateRGB(myColorImage2)
myColorImage2( : |  0 )     = xp
myColorImage2( : |  1 )     = y
myColorImage2( : |  2 )         = z
view myColorImage2


print "done"
```

and Bitwise AND operator

Syntax: and(x, y)

Description: Perform bitwise AND operator treating input arguments as unsigned 64 bits integers. Input arguments can be also real ARRAYs; in this case, the bitwise AND operator is performed on corresponding elements.

Example:

```
[ready]: x = 3; y = 5;
[ready]: and(x, y)
   1.00
```

aoi Active Region of Interest

Syntax: image.**aoi**

Description: **This command lists the pixel values within a previously selected region of interest.**

***Note**: The region of interest must be of conservative size considering the requirements to list all values within the region.*

asin Inverse Sine

Syntax: **asin**(a) or a.**asin**

Description: Compute the inverse sine of each array element. The output is in radians. The actual mathematical expression computed is given by,

$c_{j,i} = \mathrm{a}\sin(a_{j,i})$ for all j, i;

where j and i are row and column indices respectively.

Example: The following MSHELL statement will compute the inverse sine of 'a', and store the result in 'c'.

[ready]: c = asin(a);

atan *Inverse Tangent*

Syntax: **atan**(a) or a.**atan**

Description: Compute the inverse tangent of each array element. The output is in radians. The actual mathematical expression computed is given by,

$c_{j,i} = \text{atan}(a_{j,i})$ for all j, i;

where j and i are row and column indices respectively. The returned values are between **$-\pi/2$** and **$+\pi/2$**.

Example: The following MSHELL statement will compute the inverse tangent of 'a' and store the result in 'c'.

```
[ready]: c = atan(x);
```

atan2 *Inverse Tangent*

Syntax: **atan2**(y,x)

Description: Computes the inverse tangent of each array element. The output is in radians. Returns the arc tangent of y/x (in the range **$-\pi$** to **$+\pi$**); **atan2** produces correct results even when the resulting angle is near **$-\pi/2$** or **$+\pi/2$** (i.e. x near 0).

Note that the input values must be in the range of **-1** to **+1**, otherwise incorrect results will be generated, also note that if both x and y are set to 0, **atan2**(y,x) is set equal to **1**.

- B -

blackw *Blackman-Harris Window*

Syntax: **blackw**(n,m)

Description: Generates a 2-D (4 coefficient) Blackman-Harris Window. The n^{th} element of the 1-D Blackman-Harris Window is defined as,

$$w_n = c_0 - c_1 \cdot \cos(\frac{2\pi}{N} n) + c_2 \cdot \cos(\frac{2\pi}{N} 2n) + c_3 \cdot \cos(\frac{2\pi}{N} 3n)$$

where,

$$c_0 = 0.35875,\ c_1 = 0.48829,\ c_2 = 0.14128,\ \text{and}\ c_3 = 0.01168.$$

This window has side lobes that are -92dB below the main lobe.

Example: The following generates a 256 x 256 Blackman-Harris Window.

```
[ready]: y = blackw(256,256)
[ready]: [YSpectrum] = spectrum[y]
[ready]: view Yspectrum
[ready]: roi = wdef(256-16,256-16,32,32)
[ready]: plot3d(YSpectrum(roi)) // TBD IN ACT-REACT
```

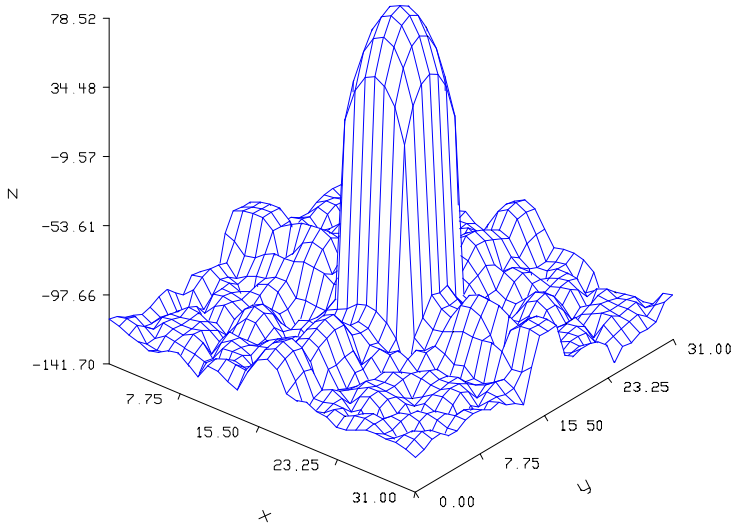


Figure 7 Sample plot of Blackman-Harris window

blinterp Bi-linear Interpolation

Syntax: **blinterp**(f,z)

Description: Blinterp will bi-linearly interpolate between data points located in a two dimensional square grid, e.g. an image. Where 'f' is a 2-dimensional real data array containing the input image. The data points in 'f' correspond to points in a square grid with an assumed interpixel distance of 1 in the row or column axis and 'z' is a complex data array containing the vertices at which the input image is to be bi-linearly interpolated. Specifically, the real part of 'z' contains the fractional column positions and the imaginary part contains the fractional row positions at which the input image is to be interpolated. Note that for every point that extrapolation is attempted the result is set to the system variable 'M_no_data'. The value of this variable can be modified by the MSHELL user.

Example: The following example generates a simple test pattern image over a 4x4 grid. The image is then bilinearly interpolated at the row coordinate 2.2 and column coordinate 1.2.

```
[ready]: f = hammiw(4,4)    // test image
[ready]: f
row 0 =
  0.01   0.04   0.08   0.04
row 1 =
  0.04   0.29   0.54   0.29
row 2 =
  0.08   0.54   1.00   0.54
row 3 =
  0.04   0.29   0.54   0.29
[ready]: x = complex( 2.2, 1.2)
[ready]: blinterp(f,x)
        0.573856
```

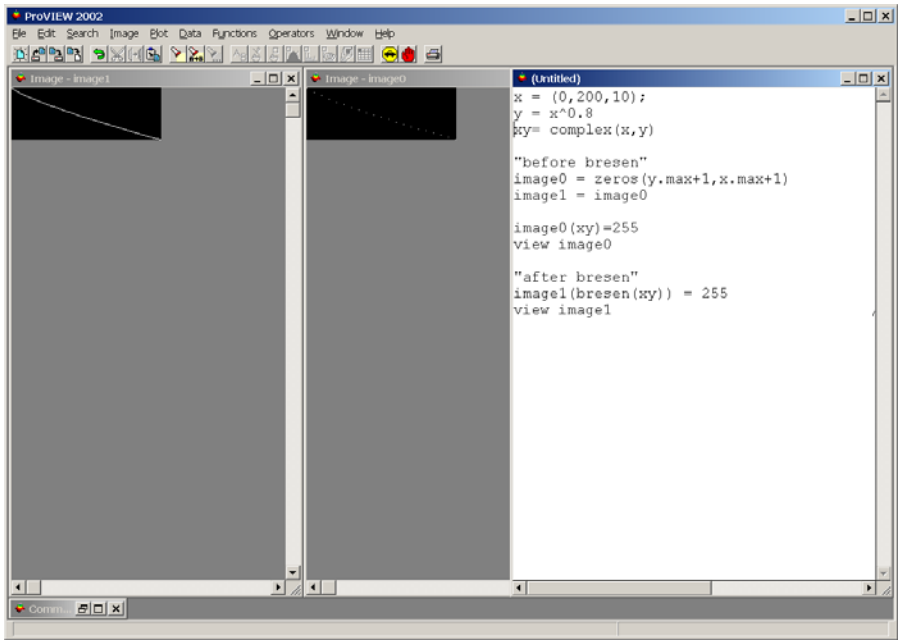
bresen *Compute Line Segment Points*

Syntax: **bresen**(z) or z.**bresen**

Description: Given the coordinates of two or more end points in the plane, this function computes the points along the line segment between the points using the Bressenham's Line Drawing Algorithm. This function is particularly useful to define a region of interest make out of line segments. The argument 'z' is a complex row data vector in which the nearest integer of the real part of z is used as the column positions, and the nearest integer of the complex part of z as the row positions.

Example: The following uses **bresen** to connect to points in a list.

```
x = (0,200,10);
y = x^0.8           // generate points on a parabola
xy= complex(x,y)

"before bresen"
image = zeros(y.max+1,x.max+1)

image(xy)=255
view image

"after bresen"
image = image*0
image(bresen(xy)) = 100
view image
```



bthresh Binary Threshold

Syntax: **bthresh**(a,tval)

Description: Given an input array, 'a', and a threshold value, 'tval', this function returns a clipped version of the input array. That is, every element in the input array less than the real threshold value is set to zero, and every element greater or equal than the threshold value is set to 1.

Example: The following illustrates the use of bthresh.

```
[ready]: z = (0,5,1,4);
[ready]: z
row 0 =
  0.00   1.00   2.00   3.00   4.00   5.00
row 1 =
  0.00   1.00   2.00   3.00   4.00   5.00
row 2 =
  0.00   1.00   2.00   3.00   4.00   5.00
row 3 =
  0.00   1.00   2.00   3.00   4.00   5.00
[ready]: bthresh(z,3)
row 0 =
  0.00   0.00   0.00   1.00   1.00   1.00
row 1 =
  0.00   0.00   0.00   1.00   1.00   1.00
row 2 =
  0.00   0.00   0.00   1.00   1.00   1.00
row 3 =
  0.00   0.00   0.00   1.00   1.00   1.00
```

- C -

ceil Find the Ceiling of an Array

Syntax: **ceil**(array);

Description: This function is used to find the ceiling of an array. The output has the same dimensions as the original array. The output contains the ceiling for each element. In essence in returns the closest integer above the value provided. Other related functions are int(), nint().

Example: [ready]: x = ceil(1.2::3.4)

row 0 =

2.0 4.00

centroid computes centroid

Syntax: **centroid(x,1)**

Description: computes the centroid based on the amplitude values in an image. This function uses all pixels in the image for the computation.

closef Close a File

Syntax: **closef**(unit);

Description: This function is used to close a disk file previously opened using the **openf**() function. It's argument, 'unit' is the integer file number assigned when **openf** was initially invoked. Failure to close a file could result in a future error when doing disk i/o.

See Also: **openf**

cmirror Mirrors an Image Column Wise

Syntax: **cmirror**(a) or a.**cmirror**

Description: Mirrors the columns of the input array or image, 'a'.

Example: The following illustrates the operation on the array 'aa'.

```
[ready]: aa = (1::2::3)#(4::5::6)#(7::8::9)
[ready]: aa
row 0 =
  1.00   2.00   3.00
row 1 =
  4.00   5.00   6.00
row 2 =
  7.00   8.00   9.00
[ready]: cmirror(aa)        // print mirror array of aa
row 0 =
  3.00   2.00   1.00
row 1 =
  6.00   5.00   4.00
row 2 =
  9.00   8.00   7.00
```

cmplxoverlap 2-D range index

Syntax: **cmplxoverlap(x,roi)**

Description: UNDER CONSTRUCTION

colplot Plots a Row from an Array [TBD in ACT-REACT]

Syntax: **colplot[N]**(array,column#)

colplot[N](array, -1) ← for interactive plot

Description: Used to plot a particular column from an array. See also rowplot().

complex Creates a Complex Array

Syntax: **complex**(x,y)

Description: Given 'x' and 'y' as real arrays with equal dimension, this function constructs an array, 'z', of the form z = x+iy, where i = sqrt(-1).

Example: The following is a simple application of the function.

```
[ready]: complex(0::3,4::3)
(10^0) X
row 0 =
  0.00+  4.00i   3.00+  3.00i
```

conj *Array Conjugate*

Syntax: **conj**(a) or a.**conj**

Description: This function returns the complex conjugate of each element in the input array 'a' , i.e. it changes the sign of the complex part.

Example: For example, if x = 4+3i, then **conj**(x) returns 4-3i.

contour *Generates a contour plot*

Syntax: **contour**[#](z,zlevels) or **contour**[#](z,yaxis,xaxis,zlevels)

Description: This function generates a contour plot of the image or sub image region selected where: 'z' is a real array, with at least 2 rows and 2 columns; 'zlevels' is the row vector with the contour levels that will be used; and '#' is the Plot Screen Number.

Instead of 'zlevels' you can use the following instruction to generate 11 different levels between the maximum and minimum value of z:

z.min+(z.max-z.min)*(0,1,0.1)

.The '#' parameter in the contour function is an optional integer number (between 0 and 255) that selects the plot screen where the plot will be placed. If an integer number from 0 to 255 is provided in this field the generated plot can be indexed from then on by that number. For example, if x is an array, then

contour3(z,0.5::0.75)

will plot a contour plot of array 'z' on plot screen number 3, using for contour levels 0.5 and 0.75. The second way of calling contour allows to specify the values to use in for the x-axis and y-axis. If later on you want to free that screen type:

free plot3

See Also: "M_" for a complete list of system variables which affect the plot related functions.

Example: The following MSHELL instructions generate a 32 x 32 hamming function, which is then stored in 'x', and then used to generate a contour plot of 'x'.

```
M_xlabel = "row index"; M_ylabel = "column index"
x = hammiw(32,32)
contour10(x,x.min+(x.max-x.min)*(0,1,0.3))
contour(x, (0,31,1)*10,  (0,31,1)*0.1, 0.5)
```

convex_hull *Find the convex hull of a set of points*

Syntax: **convex_hull**(points)

Description: This function finds the convex hull (or convex envelope) of the input set of points *points*. The convex hull is the smallest convex set that contains the input set of points. It returns the subset of points composing the convex hull.

convol *Discrete Convolution*

Syntax: **convol**(k,a)

Description: This function performs the discrete convolution of a given array, 'a', with a kernel array, 'k'. The implementations used in **convol** and **convolt** are computationally efficient for small kernel sizes. However, for large kernels, an **FFT** implementation of the convolution should be considered.

Given an image and the right kernel this function can be used to change the spatial resolution in the image.

Given that array 'a' has dimensions (N x M),

$$a \rightarrow \begin{pmatrix} a_{0,0} & a_{0,1} & \cdots & a_{0,M-1} \\ a_{1,0} & a_{1,1} & \cdots & a_{1,M-1} \\ \vdots & \vdots & \cdots & \vdots \\ a_{N-1,0} & a_{N-1,1} & \cdots & a_{N-1,M-1} \end{pmatrix}$$

it is assumed that 'a' is zero for any index outside of the implicit range specified above. It is required that the kernel, 'k', be of odd dimension, say (2P+1 x 2Q+1), where P and Q are non-negative integers satisfying:

$$2P+1 \le N, \text{ and } \quad 2Q+1 \le M.$$

The input kernel samples are assumed to map into a row range of (-P to P) and a column range of (-Q to Q) ,

$$k \rightarrow \begin{pmatrix} k_{-P,-Q} & \cdots & k_{-P,+Q} \\ \vdots & \cdots & \vdots \\ k_{+P,-Q} & \cdots & k_{+P,+Q} \end{pmatrix}$$

The result of the convolution is the array 'g', whose elements $g_{j,i}$ are given by,

$$g_{j,i} = \sum_{p=-P}^{P} \sum_{q=-Q}^{Q} (k_{p,q} \cdot a_{j-p,i-q}),$$

By construction, indices outside of the specified range of values in the above 'g' matrix are zero. Note that the output of **convol** will have dimensions of (N+2P, M+2Q).

See Also: **"convolt"** below

Example: **"convolt"** below

convolt *Truncated Discrete Convolution*

Syntax: **convolt**(k,a)

Description: This function is similar to convol; in many instances you may only be interested in determining how the elements in the range of 'a' are affected by the convolution operation. This function truncates the convolution results by only evaluating 'g' over the range of 'a' , i.e., a row range of (0 to N-1) and a column range of (0 to M-1).

The implementations used in **convol** and **convolt** are computationally efficient for small kernel sizes. However, for large kernels, an **FFT** implementation of the convolution should be considered.

Example: For arrays 'a' and 'k' as define, **convol** and **convolt** are given as:

```
[ready]: a = (1,3,1)
[ready]: k = (3,1,1)
[ready]: convol(a,k)        // example of convol
row 0 =
  3.00   8.00  14.00   8.00   3.00
[ready]: convolt(a,k)       // example of convolt
row 0 =
  8.00  14.00   8.00
```

convpolygonorient *Computes the orientation of a convex polygon*

Syntax: result = convpolygonorient(poly)

Description: This function computes the orientation of a convex polygon, given the coordinates of its vertices. The coordinates are specified as a complex row vector. The polygon is not required to be closed, so the last vertex can be different from the first one. Note: this command is faster than **polygonorient** command that finds the orientation of a generic polygon.

Return values:

0 The given polygon is degenerate

1 Means Clock-Wise orientation (CW)

-1 Means Counter-Clock-Wise orientation (CCW)

See Also: polygonorient

---

convtoi Convert Row Vector to Image

Syntax: **convtoi**(a,ncols)

Description: Converts a 1-D row array , 'a', to a 2-D array where you specify the column dimension, 'ncols'. The resulting number of rows must be an integer. That is, if the row vector had dimensions (1 x M), and the you are questing a column dimension of N, the output array will have dimensions of ((M/N) x N),i.e. N must be a factor of M.

Example: The following converts the row array , 'a', to a 2-D array.

```
[ready]: a = 1::2::1::2 // create row vector
[ready]: convtoi(a,2)       // convert row vector to 2-col. array
row 0 =
  1.00   2.00
row 1 =
  1.00   2.00
```

---

convtov Convert Image to Row Vector

Syntax: **convtov**(a) or a.**convtov**

Description: Converts the 2-D input array to a 1-D array containing only one row. That is, if the input array, 'a', had dimensions (N x M), the output array will have dimensions of (1 x (N * M)).

Example: The following converts the 2-D array, 'a', to a row array.

```
[ready]: a = (1,2,1,2)      // creates a 2x2 matrix
[ready]: a
row 0 =
  1.00   2.00
row 1 =
  1.00   2.00
[ready]: convtov(a)     // converts matrix to row vector
row 0 =
  1.00   2.00   1.00   2.00
```

copyPixelsNEQto Copy pixel values with inequality constraint

Syntax: **copyPixelsNEQto**(inarray, outarray, value)

Description: Copy pixel values from 'inarray' to 'outarray' that are NOT equal to 'value' and returns a status value (0 = successful). 'inarray' and 'outarray' can be complex ARRAYs and 'value' can be a complex scalar.

Example: The following is an example of use.

```
[ready]: a = (1::2)#(3::4)
[ready]: a
row 0 =
  1.00   2.00
row 1 =
  3.00   4.00
[ready]: b = zeros(2, 2)
[ready]: b
row 0 =
  0.00   0.00
row 1 =
  0.00   0.00
[ready]: s = copyPixelsNEQto( a, b, 2 )
row 0 =
  1.00   0.00
row 1 =
  3.00   4.00
```

cos *Cosine*

Syntax: **cos**(a) or a.**cos**

Description: Returns the cosine of each array element. The input is expected to be in radians.

Example: The following MSHELL statement will compute the cosine of 'a' divided by 2, and store the result in 'c'.

```
[ready]: c = cos(a/2)
```

cosh *Hyperbolic Cosine*

Syntax: **cosh**(a) or a.**cosh**

Description: Computes the hyperbolic cosine of each array element. The hyperbolic cosine of x is evaluated as:

$$\cosh(x) = \frac{e^{x} + e^{-x}}{2}$$

covm *Covariance Matrix Estimation*

Syntax: **covm**(a) or a.**covm**

Description: Computes an unbiased estimate of the covariance matrix established by the column vectors in 'a'. The actual estimation is done using the following equation,

$$\frac{1}{I-1} \cdot \sum_{i=0}^{I-1} (a_i - a_c)(a_i - a_c)^t$$

where, a_i is the i^{th} column in 'a', and a_c = **sumc**(a) is the column vector resulting by averaging each row in 'a'.

See Also: Fukunaga, K., "Introduction to Statistical Pattern Recognition", for a detailed definition.

Example:

```
x = randg(100,100)      // array of gaussian random  numbers
y = randg(100,100)+0.3*x// another array of gaussian random numberes

z = convtov(x)#convtov(y)//each column in z is an xy pair columnvector
covm(z)                 // estimated covariance matrix
```

crism_frame_extract Decompress raw CRISM image frame from FITS file

Syntax: decomp = **crism_frame_extract**($fits_filename)

Description: This command is MRO mission specific and was used during CRISM instrument calibration. It decompresses a raw CRISM image frame (including CCD line numbers) from a FITS file *$fits_filename* collected during ground calibration.

cspline_eval Evaluate a cubic spline at desired points

Syntax: **cspline_eval**(xi, yi, y2nd, xgrid)

Description: This command evaluates the cubic spline initializes by the *cspline_init* command at the desired *xgrid* points. *Xi* and *yi* are the initial samples as passed to the *cspline_init* command and *y2nd* are the second derivatives at each input sample as returned by the *cspline_init* command.

See Also: **cspline_init**

cspline_init Initialize a cubic spline

Syntax: **cspline_init**(xi, yi, yp1, ypn)

Description: This command initializes a cubic spline given the input sample points (*xi*, *yi*).and the first derivatives at the endpoints. *Xi* and *yi* must be ordered such that *x1* < *x2* < *x3…* and *y1* < *y2* < *y3…*
This command returns the second derivatives at each input sample, which are the input parameter of the *cspline_eval* command.

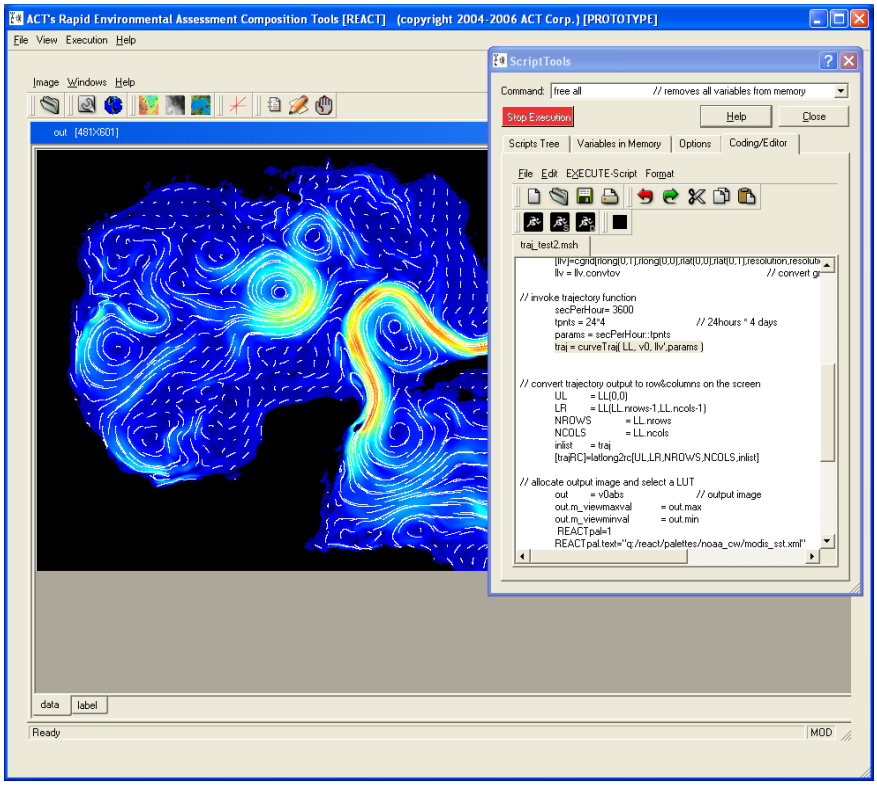
See Also: **cspline_eval**

curveTraj particle Trajectory flow builder

Syntax: **traj = curveTraj(LL, v0, posStart,params)**

Description: Computes trajectory flow of particles by solving the LaGrange equations with marching and iteration. Note: The original implementation of this algorithm was in FORTRAN and provided by Dr. Ko at NRL/SSC. The inputs to this routine are:

- **LL** – latitude and longitude planes (complex array). Values are in degrees decimal
- **v0** – complex array with user provided velocity (cm/sec) components in U (east positive) and V (north positive), i..e. v0 = complex(U,V). This array has the same dimensions as 'LL'
- **posStart** – complex column vector (Nx1) with longitude and latitude positions to use as starting point. Input is in degrees decimal.
- **params** – row vector with interval value of seconds to use, and number of points to use in the tracing, e.g. params=deltaT::num_points.
- **Traj** – return complex array with trajectories computed. The dimension of this array is (posStart.ncols X num_points). Each row is a single particle trajectory. The first point in the row corresponds to the starting input position.



```
// read the lat&long+U&V components (in raw form)
$fname=M_proviewdir::"/../ACT-
REACT_data/nasa_ca/nrl/netcdf/u3d_2004110900.nc"
[u,LL,depth,time] = ncom4d_nc_extract[$fname]

$fname=M_proviewdir::"/../ACT-
REACT_data/nasa_ca/nrl/netcdf/v3d_2004110900.nc"
[v,LL,depth,time] = ncom4d_nc_extract[$fname]

LL = rmirror(LL)
roi = wdef(0,0,LL.nrows,LL.ncols)
v0 = rmirror( complex(u(roi|0),v(roi|0)) )  // will hold the inputs
u_x&v_y
groi = eqindex(v0.real,-99)         // set no velocity over ground
v0(groi)=complex(0,0)           // set to 0 those points for which
                              //we do not have valid data values
v0abs = v0.abs
view v0abs

// select starting trajectory points to use
resolution = 0.5
rlong= maxmin(LL.real)
rlat= maxmin(LL.imag)
[llv]=cgrid[rlong(0,1),rlong(0,0),rlat(0,0),rlat(0,1),resolution,resolu
tion]

// create a grid of interesting points
llv = llv.convtov           // convert grid to a vector

// invoke trajectory function
secPerHour= 3600
tpnts = 24*4                // 24hours * 4 days
params = secPerHour::tpnts
traj = curveTraj( LL, v0, llv',params )

// convert trajectory output to row&columns on the screen
UL= LL(0,0)
LR= LL(LL.nrows-1,LL.ncols-1)
NROWS= LL.nrows
NCOLS= LL.ncols
inlist= traj
[trajRC]=latlong2rc[UL,LR,NROWS,NCOLS,inlist]

// allocate output image and select a LUT
out= v0abs              // output image
out.m_viewmaxval = out.max;    out.m_viewminval= out.min
REACTpal=1
REACTpal.text="q:/ACT-REACT/palettes/noaa_cw/modis_sst.xml"
[REACTrgb]=get_noaa_palette[REACTpal]
 if( ncols(out.LUT   )==0){
       out.LUT    = (0,255,1,3)
 }
 if( ncols(out.LUTdef)==0){
```

```
      out.LUTdef = out.LUT
}
out.LUT=REACTrgb
out(trajRC.convtov)=100;

lastpos = trajRC(:,trajRC.ncols-1)
out(lastpos')=255
 out(groi)= 0;
view out
wtile
```

- D -

---

dbclose *Closes access to an external database*

Syntax: **dbclose()**

Description: Use this command to close the alerady opened database.

Example: see dbrsgetrows example

---

dbrsrowcount *Returns the result set count*

Syntax: **dbrsrowcount()**

Description: This function works after a dbconnect and dbsqlexec. After a query this function when invoked will return the number of rows in the result set.

Example: see dbrsgetrows example

---

dbrsgetrows *Returns the result set as a string data.*

Syntax: **dbrsgetrows(**srow,erow**)**

dbrsgetrows(srow,erow,$fname**)**

dbrsgetrows($colnames,srow,erow**)**

dbrsgetrows($colnames,srow,erow,$fname**)**

where,

srow – start row number

erow – end row number

$fname – output file name (string)

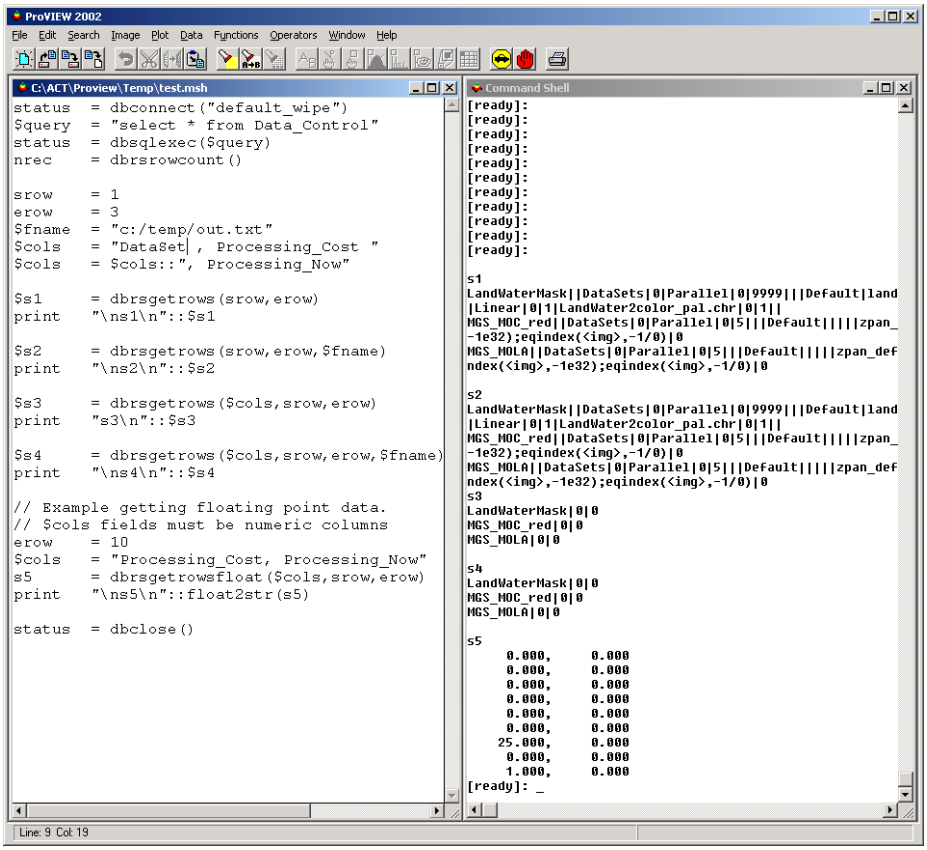
$colnames – list of requested field names

Description: This function works after a dbconnect and dbsqlexec. After a query this function when invoked will return the result set data as a string. The columns are separated by a | and rows are

separated by new lines. This function may be called multiple times on the same result set. . There are different ways to extract the results of the query using this function

Example: The following example shows most of the dbrs… function being utilized on a simple test case.

```
status              = dbconnect("default_wipe")
$query              = "select * from Data_Control"
status              = dbsqlexec($query)
nrec                = dbrsrowcount()

srow                = 1
erow                = 3
$fname  = "c:/temp/out.txt"
$cols   = "DataSet , Processing_Cost "
$cols               = $cols::", Processing_Now"

$s1                 = dbrsgetrows(srow,erow)
print               "\ns1\n"::$s1

$s2                 = dbrsgetrows(srow,erow,$fname)
print               "\ns2\n"::$s2

$s3                 = dbrsgetrows($cols,srow,erow)
print               "s3\n"::$s3

$s4                 = dbrsgetrows($cols,srow,erow,$fname)
print               "\ns4\n"::$s4

// Example getting floating point data.
// $cols fields must be numeric columns
erow                = 10
$cols               = "Processing_Cost, Processing_Now"
s5                  = dbrsgetrowsfloat($cols,srow,erow)
print               "\ns5\n"::float2str(s5)

status              = dbclose()
```



dbconnect *Connects to database for access .*

Syntax: **dbconnect** ($database)

Description: Use this command to connect to an external datbase. The string passed is the name which has been previouly defined for the database in the ODBC administration tool. Returns a value of **zero** if it is successful.

Example: see dbrsgetrows example

dbrsgetrowsfloat *Returns the result set as an array.*

Syntax: **dbrsgetrowsfloat(**srow,erow**)**

dbrsgetrowsfloat(srow,erow,$fname**)**

dbrsgetrowsfloat($colnames,srow,erow**)**

dbrsgetrowsfloat($colnames,srow,erow,$fname**)**

where,

srow – start row number

erow – end row number

$fname – output file name (string)

$colnames – list of requested field names

Description: This function works after a dbconnect and dbsqlexec. After a query this function when invoked will return the result set data as an array. The first input argument $column_name is a comma separated list of column names to be retrieved. This function may be called multiple times on the same result set. If your are retrieving a large number of numeric related records this function executes significantly faster than 'dbrsgetrows'.

Example: see dbrsgetrows example

---

dbsqlexec Sends a query to the database

Syntax: **dbsqlexec($query)**

Description: This function executes a query on the connected server, it is used after a dbconnect . Returns a value of zero if it is successful.

Example: see dbrsgetrows example

---

dbfopen Returns a handle to the opened dbf file

Syntax: **dbfopen($dbffile)**

Description: this function returns a handle to the opened dbf file if it succeeds, otherwise it returns –1. You can open up to 5 dbf files at a time.
Note: In MS-Windows a dbf file **can also** be accessed using the Visual FoxPro ODBC driver. All the functions of the type dbf___ are for giving access to the dbf file. These functions do not provide SQL query capability.

Example:

```
$dbffile = "../../ACT-REACT_data/global/place_find/country.dbf"

hdbf                = dbfopen($dbffile)     // get handle

fldcnt              = dbfgetfieldcnt(hdbf)  // get number of
fields/record and name of the fields
print               "number of records="::int2str(fldcnt)
print               "\nThe field names are:\n"
print               fldcnt.text                 //names of the fields
print               "\n"


nrec                = dbfgetrecordcnt(hdbf) // get number of records
print               "number of records are: " :: int2str( nrec)::"\n"

$rec = dbfgetrecords(hdbf,-1,-1)    // read all the records
print "showing the content of the 1st 3 records..\n"
$rec(0:2,:)

status              = dbfclose(hdbf)            // close the handle
```

dbfclose This function closes the dbfile

Syntax: **dbfclose(hdbf)**

Description: this function closes the dbffile. It makes the handle available for a subsequent call to dbfopen.

Example: see example in dbfopen( )

dbfgetfieldcnt returns the # of fields in the dbf file.

Syntax: dbfgetfieldcnt(hdbf)

Description: this function returns the number of fields present in the dbf file. It also returns the names of the fields in the text attribute of the returned array variable.

Example: see example in dbfopen( )

dbfgetrecordcnt returns the # of records in the file

Syntax: **dbfgetrecordcnt(hdbf)**

Description: This function returns the number of records in the dbf file .

Example: see example in dbfopen( )

---

dbfgetrecords read the records from the dbf file.

Syntax: **dbfgetrecords(hdbf,-1,-1)**
dbfgetrecords(hdbf,recVec,fieldVec)

Description: This function is used to read the records from the dbf file. The input parameters are the
hdbf - dbffile handle,
recVec - an arrary variable containing the record indices (zero based) you wish to extract. If set to -1, then all records are extracted.
fieldVec - an array variable containing the field indices (zero based) you want to extract. If set to -1, then all fields are extracted.

The output is a string containing the field values, separated by '|', for the specified rows or all the rows .

Example: see example in dbfopen( )

dbrsgetcolnames — *Returns column names in a result set*

Syntax: **dbrsgetcolnames** ()

Description: Returns a comma separated list of the column names in a result set. To be called after a SELECT query call to sqlexec(). Any expressions in the SELECT statement may be returned as an empty column name (DB driver dependent), unless the AS operator is used. The column name should match the AS identifier properly.

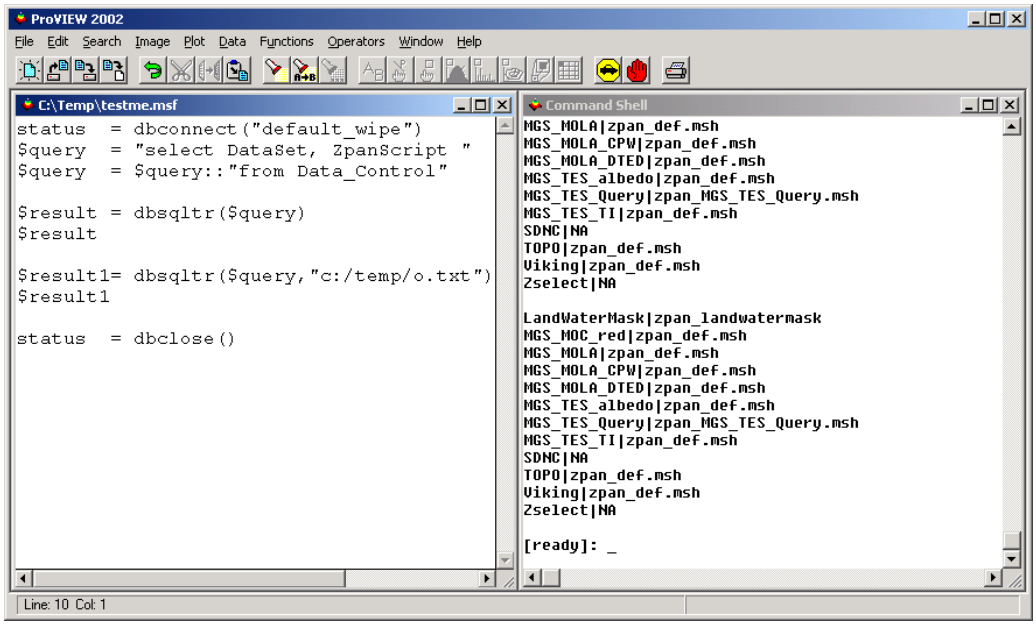
dbsqltr — *Transacts with an external database*

Syntax: **dbsqltr(**$query,<$filename>**)**

Description: Use this command to post the passed string as the next query for the previously connected database. The output of the query, if any, is automatically retrieved. The records are extracted and string formatted. The fields are delimited by the character '|'. The output is assigned to a string variable if the optional filename parameter is not specified; otherwise, the output is saved to the named file.

Example:

```
status              = dbconnect("default_wipe")
$query              = "select DataSet, ZpanScript "
$query  = $query::"from Data_Control"

$result = dbsqltr($query)
$result

$result1= dbsqltr($query,"c:/temp/o.txt")
$result1

status              = dbclose()
```



dct8x8 Discrete Cosine Transform (8x8)

Syntax: **dct8x8**(a)

Description: Computes the discrete cosine transform of each 8 x 8 block within the specified array "a".

decimate Signal Decimation

Syntax: **decimate**(a,rowskip,columnskip)

Description: Extracts a sub-sampled version of the input signal, where: 'a' is the input array, 'rowskip' and 'columnskip' are the number of rows and columns, respectively, to be skipped in each direction.

Example: A 512 x 512 input image, 'a', can be decimated to a 128 x 128 image, 'b', using the following MSHELL statement,

```
[ready]: b = decimate(a,4,4);
```

dirlist Returns the list of subdirectories/files

Syntax: dirlist($path ,$options) or sys_dirlist($path,$optons)

Description: This function returns the list of the subdirectories or files of a given directory. The first input argument is a string, containing the directory name. The second input argument is one of the following "d" , "s" or, "p" .
When "d" is used the function will return only the list of subdirectories. Otherwise only the files are listed. When "s" is used the function will return the list of files along with their size. When "p" is used the function will list the path of the files .
Note: this function uses '|' as the delimiter.

Example:

```
// to print directories, their sizes, and the full path
$out = dirlist("c:\\temp\\*.*", "dsp" )


// to print the directory listing only.  This will not print files
$x = dirlist("F:/crism_pds_archive/trdr/TRDR/*","d")
```

diskfreespace returns disk info

Syntax: **diskfreespace("c:/temp")**

Description: This function returns an array variable containing three values. The first value is the total number of bytes in the disk, the second value is the total number of free bytes in the disk, and the third value is the total number of free bytes per caller (this can be used if disk quotas are setup per user). The input argument is a string containing a path (UNC are allowed).

Example:

```
[ready]: freespace = diskfreespace("e:\\")
[ready]: freespace = diskfreespace(\\\\hyper\\cdrive)
```

---

dt2mjd *Returns the modified Julian Date*

Syntax: **dt2mjd(Year::Month::Day::Hour::Minute::Second)**

Description: This function returns the modified Julian date, the input argument is year, month, day, hour, minute, and seconds (includes fractions of seconds).

Note: In the single precision version of MSHELL, using mjd2dt after dt2mjd is accurate to within minutes. In the double precision version it is accurate to mseconds.

Example: **see tdiff()**

See Also: **m2spice_**.... related functions for support in time computations across different time reference systems, e.g. UTC, Ephemeris Time, Missions-Ellapsed Times, …

---

dworld *draws world coastline map*

Syntax: **dworld**(llrange,outcntl)

or

dworld(xyrange,outcntl**)**

Description: There are two modes of usage for this function. Both modes use the world data file pointed by the system variable 'M_wdb'. *Under your MSHELL installation directory, see the subdirectoy 'wdb' for a list of possible files to use.*

F**irst usage mode -** In this mode , 'dworld', generates an image corresponding to the coastline map of the world for the selected range of latitudes and longitudes (in degrees). In this mode the output map is generated faster and in simple cylindrical type of projection.

llrange – a 1x4 row vector that determines the area of interest in latitude and longitude, e.g.
llrange = latmin::latmax::longmin::longmax

outcntl – a 1x2 row vector that control the number of rows and columns in the output image, e.g. coldim = 300::600 will. It is optional to add a third parameter to 'outcntl'. This third parameter can be used to read every

'gap' pixel from the input world data file. For example if the output image is 300 rows and 400 columns and you desire to read every 25th point from the input world data file then, coldim = 300::400::25.
The maximum gap value recommended is 45. For global coverage large gap sizes can be used, but for small map areas of interest smaller values in the gap size generate a more accurate coast line output. The default value of gap is internally adaptive depending on the coverage size of the selected area.

Second usage mode – In this mode 'dworld' generates the output in any of the supported cartographic projections accessible via the function 'Geo2Cart()'.

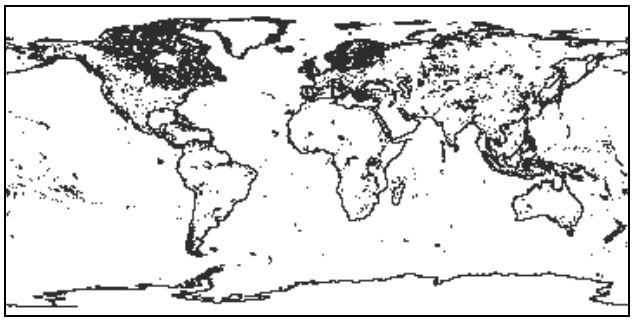
xyrange - a 1x4 row vector, corresponding to the desired region in the cartographic domain (default units are meters), .e.g..
xyrange= ymin::ymax::xmin::xmax
xyrange.text –must be set to the desired **proj4** string (see examples and Geo2Cart() description). If 'dworld' detects any content in xyrange.text it will assume that the user is interested in generating its output as a cartographic map.

outcntl – same as above definition

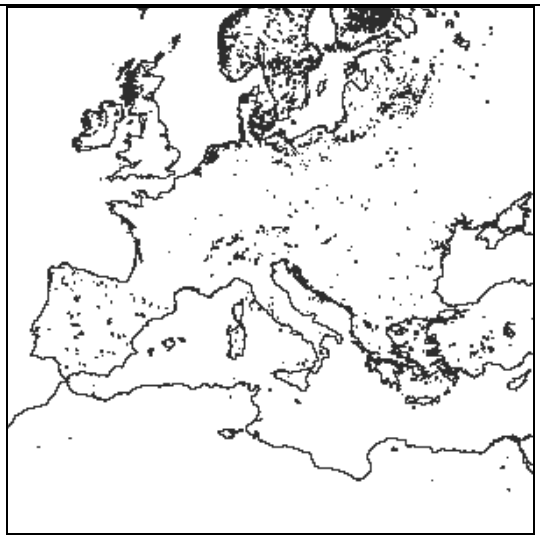
See Also: wdbmap.msf, MI_geo2cart.msf , Geo2Cart(), Map_Image.msf, Map_Images.msf

Example:

```
M_wdb = "C:/ACT/Proview/wdb/coasts.dat"  // use coast line
weqc = dworld(-90::90::-180::180,180::360)
weqc = 255-weqc     // negate the image to force white background
view255 weqc
```

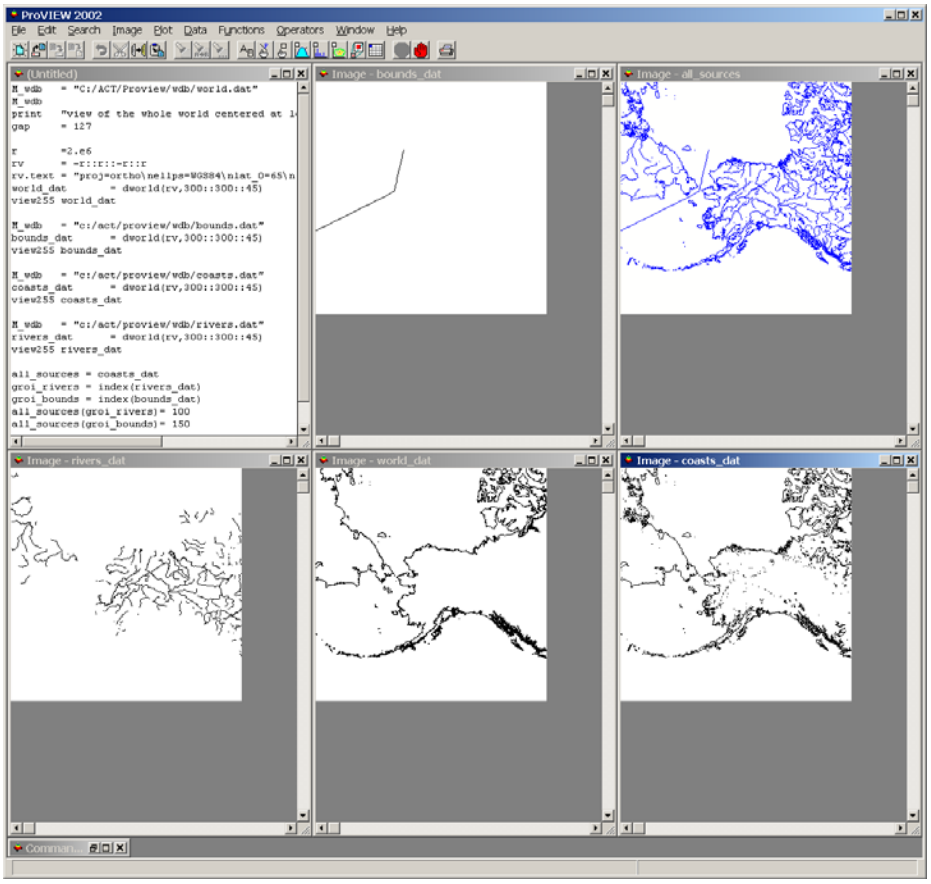


```
r                       = 2.0e6
range                   = -r::r::-r::r
range.text = "proj=ortho \nellps=WGS84 \nlat_0=45 \nlon_0=12\nno_defs"
range.text = smodify(range.text," ","");  // remove spaces
wview                   = dworld(range,300::300)
wview                   = 255-wview
view255             wview
```



The following example shows sample output from all the input files that can be accessed via the M_wdb variable. The input data use here comes from the CIA vector shoreline publicly available.

```
M_wdb               = "C:/ACT/Proview/wdb/world.dat"
M_wdb
print               "view of the whole world centered at longitude 0\n"
gap                 = 127

r                   =2.e6
rv                  = -r::r::-r::r
rv.text             = "proj=ortho\nellps=WGS84\nlat_0=65\nlon_0=-
155\nno_defs" // center on Alaska
world_dat           = dworld(rv,300::300::45)
view255 world_dat

M_wdb               = "c:/act/proview/wdb/bounds.dat"
bounds_dat          = dworld(rv,300::300::45)
view255 bounds_dat

M_wdb               = "c:/act/proview/wdb/coasts.dat"
coasts_dat          = dworld(rv,300::300::45)
view255 coasts_dat

M_wdb               = "c:/act/proview/wdb/rivers.dat"
rivers_dat          = dworld(rv,300::300::45)
view255 rivers_dat

all_sources = coasts_dat
groi_rivers = index(rivers_dat)
groi_bounds = index(bounds_dat)
all_sources(groi_rivers)= 100
all_sources(groi_bounds)= 150
view all_sources
```



Additional examples can be obtained by executing the following code.

```
M_wdb               = "c:/act/proview/wdb/bounds.dat"
M_wdb               = "C:/ACT/Proview/wdb/world.dat"
M_wdb
print               "view of the whole world centered at longitude 0\n"
gap                 = 45
orows               = 180
ocols               = 360
weqc                = dworld(-90::90::-180::180,orows::ocols::gap)
LLw                 = 255-weqc
view255             LLw     // equi-distance cylindrical view of the
world

M_wdb               = "C:/ACT/Proview/wdb/coasts.dat"
M_wdb
print               "view of the whole world centered at longitude 0\n"
weqc                = dworld(-90::90::-180::180,orows::ocols::gap)
LLc0                = 255-weqc
view255             LLc0    // eqc view of the world centered at long=0

print               "view of the whole world centered at longitude 0,
midpoint between 0::360\n"
weqc                = dworld(-90::90::0::360,orows::ocols::gap)
LLc180              = 255-weqc
view255             LLc180

r                   = 10e6
rv                  = -r::r::-2*r::2*r
rv.text             = "proj=sinu\nellps=WGS84\nlat_0=-
90\nlon_0=0\nno_defs"
wview               = dworld(rv,orows::ocols::gap)
sinu                = 255-wview
view255 sinu

M_wdb               = "C:/ACT/Proview/wdb/world.dat"
M_wdb
r                   = 10e6
rv                  = -r::r::-2*r::2*r
rv.text             = "proj=moll\nellps=WGS84\nlat_0=-
90\nlon_0=0\nno_defs"
wview               = dworld(rv,orows::ocols::gap)
mollweid= 255-wview
view255 mollweid

r                   =3.e6
rv                  = -r::r::-r::r
rv.text             = "proj=ortho\nellps=WGS84\nlat_0=65\nlon_0=-
155\nno_defs"
// centered on Alaska
wview               = dworld(rv,300::300::45)
ortho_AK= 255-wview
view255 ortho_AK

r                   =2.5e6
```

```
rv                  = -r::r::-r::r
rv.text             =
"proj=ortho\nellps=WGS84\nlat_0=40\nlon_0=13\nno_defs"
// centered on ITALY
wview               = dworld(rv,300::300::45)
ortho_IT= 255-wview
view255 ortho_IT
```

- E-

END *Ends Execution of a Script*

Syntax: **END**

Description: Used within a script to end the execution. It is to be placed at the end of the script when to be completed. No error condition or message is generated when this function is called.

eqindex *Equality Index*

Syntax: **eqindex**(a,b)

Description: Finds the locations of all the elements in an input array which equal a constant value, where 'a' is the input array and 'b' is the constant scalar quantity. This function returns a (1 x M) complex array, where M is the number of points equal to the specified value and whose array elements contain the coordinates of each point encoded as follows: the real part contains the column index, and the imaginary. part contains row index of the point. If no elements are matched, a NULL array is returned.

Example: Cases with matches and without are illustrated below.

```
[ready]: x = (0,5,1)
[ready]: eqindex(x,3)
3 + 0i
[ready]: y = eqindex(x,10)
--- NULL ARRAY ---
[ready]: y = eqindex(x,10)
[ready]: y.ncols
    0
```

See Also: finite_index(),not_finite_index(),gt_index, leindex(),ltindex(), geindex(), nan_index(), …The following illustrates the use of some of these functions

```
z=0                     // zero value
show z
minf = -1/0             // - infinity
show minf
nan = -1/0+1/0      // generates a Not a Number
show nan
uno = 1
show uno

v = z::minf::nan::uno   // construct a vector
v

print "index(v)         // index to elements that are not zero\n"
index(v)

print "\n finite_index(v)   // index to elements that are finite\n"
finite_index(v)

print "\n eqindex(v,z)  //index to elements equal to 0 \n"
eqindex(v,w)

print "\n eqindex(v,minf)   //index to elements equal to -infinity \n"
eqindex(v,minf)

print "\n eqindex(v,nan)    //index to elements equal to NaN \n"
eqindex(v,nan)

print "\n nan_index(v)  // index to Not-a-Number elements\n"
nan_index(v)

print "\n ltindex(v,uno)    // index to elements less than one\n"
ltindex(v,uno)

print "\n rindex(v,-1/0,1000) // index to all elements between minus
infinity and 1000\n"
rindex(v,-1/0,1000)

print "\n geindex(v,1)  // index to all elements >=1 \n"
geindex(v,1)
```

eqindexS Equality Index String

Syntax: **eqindexS**($a,$b)

Description: Finds the locations of all the elements in an input string which equal a defined substring, where '$a' is the input string and '$b' is the substring. This function returns a (1 x M) complex array, where M is the number of points equal to the specified value and whose array elements contain the coordinates of each string position encoded as follows: the real part contains the column index, and

the imaginary. part contains row index of the location. If no elements are matched, the value **-1** is returned.

See Also: The functions **strContains**($a,$b), **strStartWith**($a,$b), and **strEndsWith**($a,$b) may be more convenient to use, depending on the user needs.

Example:

```
[ready]:
[ready]: $string = "This is an example to demonstrate the use of eqindex$."
[ready]: x = eqindex$($string,"de")
[ready]: x

(10^0) X
row 0 =
 22.00-  0.00i
row 1 =
 49.00-  0.00i

[ready]: _
```

evaltext *Evaluates a String*

Syntax: **evaltext** $str

Description: This function allows you to send a string to the MSHELL interpreter for execution. You can use this function to create variable names within a script file.

Example: The following lines of code illustrate the application.

```
i = 1
$str = "x"::int2str(i)::"= hammiw(32,32)*255"
evaltext $str
view x1
num = 5
evaltext "$string = \"This is a very good manual.\""
$string
```

exit *Exit MSHELL*

Syntax: **exit**

Description: This command will exit the MSHELL Interpreter and confirm if you want to exit the MSHELL environment and, if so, return you to the host operating system.

exp *Inverse-Natural Logarithm*

Syntax: **exp**(a) or a.**exp**

Description: Computes the inverse natural logarithm of each array element in 'a', i.e., raise e to the power of each array element. The actual mathematical expression computed is given by,

$$c_{j,i} = e^{a_{j,i}} \quad \text{for all j, i}$$

where j and i are row and column indices respectively, and $e = \ln(1)$.

Example: The following MSHELL statement will compute the inverse-logarithm of 'a' and store the result in 'c',

```
[ready]: c = exp(a)
```

expand *Environment variables expansion*

Syntax: **expand(** $string **)**

Description: Expand any system environment variable contained in '$string' to its value. Environment variables must be specifed in the form '$(VAR)'.

Example:

```
[ready]: expand("Qt dir is $(QTDIR)")
                    Qt dir is D:\Qt\3.3.7
```

- F -

factorial *Factorial of input ARRAY*

Syntax: **factorial**(a) or a.**factorial**

Description: Computes the factorial of the ARRAY *a*, which can be either a scalar or a matrix. In case of a matrix, the factorial will be computed element-wise.

fft *1-D Fast Fourier Transform*

Syntax: **fft**(a) or a.**fft**

Description: Computes the one dimensional Fourier transform of the rows of the input array, 'a'. The input as well as the output of this function may be a complex array. Note that the row dimension of the input array must be a power of two.

Example: If 'a' is an input array with dimensions of 64 x 64, then the one dimensional Fourier transform of each row can be computed as, **fft**(a).

fft2 *2-D Fast Fourier Transform*

Syntax: **fft2**(a) or a.**fft2**

Description: Computes the two dimensional Fourier transform of the input array. The input as well as the output of this function may be a complex array. It is expected that the dimensions of the input array are a power of two.

Example: If 'x' is an input array with dimensions of 64 x 64, then its power spectrum in dB can be estimated using the following construction,

```
Power_spectrum = 20 * real(log10(fft2(x)))
```

See Also: spectrum.msf; Appendix B External Function

file_copy_to_stdout *Read a file and copy the content to standard output*

Syntax: status = **file_copy_to_stdout**($file)

Description: This command reads a file and copy the content to the Standard Output.

Note: this function is available only in ProVIEW Web.

fileinfo Returns detailed information of a file

Syntax: **fileinfo**($fname)

Description: Returns the size of an existing file in bytes and the date and time created. If the file does not exist it returns **-1**.

filesize Returns the size of a file

Syntax: **filesize**($fname)

Description: Returns the size of an existing file in bytes. If the file does not exist it returns **-1**.

find_key_points Find Image Key Points

Syntax: **find_key_points**(image, options)

Description: Find key points (interest points) in an image using the SURF algorithm. The most important property of a key point is its repeatability, that is the ability to find the same physical point under different view conditions. 'image' must be a gray scale image (one band image) scaled in [0-255]. 'options' is a row vector made as follows

threashold::extended[::no_data_value]

threashold defines the filter to find key points. The lower it is the more key points are found. Good default value is ~300-500 (can depend on the average local contrast and sharpness of the image)

extended controls the size of the descriptor for each key point. A descriptor is the data that describes the area around each key point. It is used to find matching points between two images. Use 0 for basic descriptors (64 elements each) or 1 for extended descriptors (128 elements each). This parameter is not very important in this command.

no_data_value is the no data value of the input image. The key points are only found in the areas that contain more than 50% of valid data.

The function returns the list of key points as a row vector. Each point is in the form complex(x, y), where x and y are double values.

See Also: find_matching_points(image1, image2, options)

find_matching_points Find Matching Points Between Two Images

Syntax: **find_matching_points**(image1, image2, options)

Description: Find matching points between two images using the SURF algorithm. 'image1' and 'image2' must be gray scale images (one band image) scaled in [0-255]. 'options' is a row vector made as follows

threashold::extended[::no_data_value]

threashold defines the filter to find key points. The lower it is the more key points are found. Good default value is ~300-500 (can depend on the average local contrast and sharpness of the image)

extended controls the size of the descriptor for each key point. A descriptor is the data that describes the area around each key point. It is used to find matching points between two images. Use 0 for basic descriptors (64 elements each) or 1 for extended descriptors (128 elements each).

no_data_value is the no data value of the input image. The key points are only found in the areas that contain more than 50% of valid data.

The function returns the list of matching points. Each point is in the form complex(x, y), where x and y are double values.

See Also: find_key_points(image, options)

findfiles Locate Files in Directory Structure

Syntax: **findfiles**($path,$type)

Description: This function can be used to find all files starting at a given directory level, '$path', and satisfying a matching criteria, '$type'. The function returns a string with all the files that satisfy the matching criteria. If '$path' contains any environment variables in the form '$(VAR)', those are expanded to their values (see "expand" command).

Example: The following returns all files with extension "chr" in c:\proview.

```
[ready]: $str = findfiles("c:\proview","*.chr")
[ready]: $str
c:\proview\IMAGES\EQOHARE.CHR
c:\proview\IMAGES\MANDEL.CHR
c:\proview\IMAGES\MSHELL.CHR
c:\proview\IMAGES\RM000.CHR
```

finite_index Index of all non-infinite elements

Syntax: **finite_index**(a)

Description: This function locates all the finite elements of variable *a* and returns a (1 x M) complex array (*M* is the number of finite values found in *a*) whose elements contain the coordinates of each point encoded as follows: the real part contains the column index, and the imaginary part contains row index of the point. If no elements are matched, a NULL array is returned.

fits_create_file — *Create an empty FITS file*

Syntax: **handle = fits_create_file**($file_name)

Description: Creates an empty FITS file, and returns a handle for use with reading and writing functions.

fits_open_file — *Open a FITS file*

Syntax: **handle = fits_open_file**($file_name, "r")

Description: Opens a FITS file, and returns a handle for use with reading and writing functions. The second parameter specifies reading ("r") or writing ("w")

Example:

```
[ready]:handle = fits_open_file("C:/NXEROS_0001/XRS00053.FIT ","fits")
[ready]: handle
1
```

fits_create_img — *Create a new HDU*

Syntax: **status = fits_create_img(** handle, bitpix, axes **)**

Description: Creates a new IMAGE extension (HDU – Header and Data Unit) with the given data type *bitpix* and the given dimensions *axes*. If the FITS file is empty a new primary IMAGE extension is created, otherwise a new IMAGE extension is appended to the file. *axes* must be a 3 elements row vector containing the sizes along the 3 axes. Returns zero upon sucessful.

fits_get_num_hdus — *Returns the number of HDUs*

Syntax: **num_of_hdus = fits_get_num_hdus(handle)**

Description: Returns the number of HDU (Header and Data Unit**)** from a previously opened fits file. Note that an HDU may consist entirely of a header with no data records.

Example:

```
[ready]: handle = fits_open_file("C:/NXEROS_0001/XRS00053.FIT ","fits")
[ready]: num_of_hdus = fits_get_num_hdus(handle)
[ready]: num_of_hdus
2
```

fits_movabs_hdu *Moves to a specified HDU*

Syntax: **hdu_type = fits_movabs_hdu(handle,hdu_number)**

Description: Moves to the specified hdu_number, so hdu_number is less or equal to num_of_hdus. HDU type:

IMAGE_HDU 0 /*Primary Array or IMAGE HDU*/

ASCII_TBL 1/*ASCII table HDU */

BINARY_TBL 2 /*Binary table HDU */

Example:

```
[ready]: handle = fits_open_file("C:/NXEROS_0001/XRS00053.FIT ","fits")
[ready]: num_of_hdus = fits_get_num_hdus(handle)  // num_of_hdus =  2
[ready]: HDU_type = fits_movabs_hdu(handle,1)
[ready]: HDU_type
0
```

fits_get_hdu_type *Returns the type of the current HDU*

Syntax: **type_num = fits_get_hdu_type(handle)**

Description: Returns the type number of current HDU. The possible types are:

IMAGE_HDU 0 /*Primary Array or IMAGE HDU*/

ASCII_TBL 1 /*ASCII table HDU */

BINARY_TBL 2 /*Binary table HDU */

Example:

```
[ready]: handle = fits_open_file("C:/NXEROS_0001/XRS00053.FIT ","fits")
[ready]: type_num = fits_get_hdu_type(handle)
[ready]: type_num    // note that
0
```

fits_get_num_keywords Returns # of existing keywords

Syntax: **num_keywords = fits_get_num_keywords(handle)**

Description: Returns the number of existing keywords (not counting END keyword).

Example:

```
[ready]: handle = fits_open_file("C:/NXEROS_0001/XRS00053.FIT ","fits")
[ready]: num_keywords = fits_get_num_keywords(x)
[ready]: num_keywords
738
```

fits_read_keyn_name Returns keyname

Syntax: **$keyname = fits_read_keyn_name(handle,keynum)**

Description: Returns a string $keyname for the key number keynum . Note that keynum can not exceed the number of existing keywords.

Example:

```
[ready]: handle = fits_open_file("C:/NXEROS_0001/XRS00053.FIT ","fits")
[ready]: num_keywords = fits_get_num_keywords(handle)
[ready]: $keyname = fits_read_keyn_name(handle,keynum) //keynum <= 738
[ready]: $keyname   // from previous example num_keywords is 738
TTYPE173            // for keynum = 647
```

fits_read_keyn_value Returns a keyvalue

Syntax: **$keyvalue = fits_read_keyn_value(handle,keynum)**

Description: Returns a string $keyvalue for the key number keynum. Note that keynum can not exceed the number of existing keywords.

Example:

```
[ready]: handle = fits_open_file("C:/NXEROS_0001/XRS00053.FIT ","fits")
[ready]: num_keywords = fits_get_num_keywords(handle)
[ready]: $keyvalue = fits_read_keyn_value(handle,keynum) //keynum <=
738
[ready]: $keyvalue         // from previous example num_keywords is 738
'unf_level_1_safing_flg'     // for keynum = 647
```

fits_read_keyn_comment Returns keyword comment

Syntax: **$keycomment = fits_read_keyn_comment(handle,keynum)**

Description: Returns keyword comment $keycomment for the key number keynum. Note that keynum can not exceed the number of existing keywords..

Example:

```
[ready]: handle = fits_open_file("C:/NXEROS_0001/XRS00053.FIT ","fits")
[ready]: num_keywords = fits_get_num_keywords(handle)
[ready]:$keycomment=fits_read_keyn_comment(handle,keynum) //keynum<=
738
[ready]: $keycomment   //from previous example num_keywords is 738
label for field 173    // for keynum = 647
```

fits_read_ keyword_value Returns Key value

Syntax: **$keyvalue = fits_read_keyword_value(handle,$keyname)**

Description: Returns a string $keyvalue for an existing name $keyname.

Example:

```
[ready]: handle = fits_open_file("C:/NXEROS_0001/XRS00053.FIT ","fits")
[ready]: $keyname = fits_read_keyn_name(handle,keynum)  //keynum = 647
[ready]: $keyvalue = fits_read_keyword_value(x,$keyname)
[ready]: $keyvalue
'unf_level_1_safing_flg'
```

fits_read_keyword_comment Returns keyword comment

Syntax: $keycomment **= fits_read_keyword_comment(** handle, $keyname **)**

Description: Returns keyword comment string for $keyname.

Example: The following MSHELL statement will compute the….

```
[ready]: handle = fits_open_file("C:/NXEROS_0001/XRS00053.FIT ","fits")
[ready]: $keyname=fits_read_keyword_name(handle,keynum)  //keynum = 647
[ready]: $keycomment = fits_read_keyword_comment(handle,$keyname)
[ready]: $keycomment
label for field 173
```

fits_update_key — *Update a keyword in the current HDU*

Syntax: status = **fits_update_key (** handle, $keyname, $value **)**

status = **fits_update_key (** handle, $keyname, $value, $comment **)**

Description: Update an existing string type keyword in the current HDU. If the optional parameters *$comment* is passed the keyword comment field is also updated, otherwise it is left unmodified or blank.

fits_get_size — *Returns the # of rows and columns*

Syntax: **size = fits_get_size(handle)**

Description: Returns the number of rows and columns in the current FITS file. Size(0,0) = number if rows and Size(0,1) = number of columns.

Example:

```
[ready]: handle = fits_open_file("C:/NXEROS_0001/XRS00053.FIT ","fits")
[ready]: size   = fits_get_size(handle)
[ready]: size
    124.0     195.0
```

fits_get_colnum — *Returns the column # of a FITS file*

Syntax: **colinfo = fits_get_colnum(handle,$template_ name)**

Description: Returns a vector of columns, and a string list in colinfo.text of colnames (newline separated) if more than one column match the pattern. $template_name is the exact name of the column to be searched for, or it may contain a wild card character(*,?,or #), or it may contain the integer number of the desired column (with the first column = 1).

Example:

```
[ready]: handle = fits_open_file("C:/NXEROS_0001/XRS00053.FIT ","fits")
[ready]: colinfo = fits_get_colnum(x,"met")
[ready]: colinfo
1
```

fits_get_coltype *Returns the column type*

Syntax: **coltype = fits_get_coltype(handle,colnum)**

Description: Returns the column type number, repeat count (vector columns). Returns 1x3 vector

Coltype(0,0) = column type number

Coltype(0,1) = repeat count

Coltype(0,2) = width

Example:

```
[ready]: handle = fits_open_file("C:/NXEROS_0001/XRS00053.FIT ","fits")
[ready]: coltype = fits_get_coltype(handle,1)  // first column
[ready]:coltype
     41.0       1.0       4.0
```

fits_read_col_values *Reads column values*

Syntax: **coldata = fits_read_col_values(handle,col,firstrow,firselem,melem) or**

coldata = fits_read_col_values(handle,col,firstrow,num_rows) or

coldata = fits_read_col_values(handle,col)

Description: Reads the column values starting with firstrow, firstelem, and continuing for nelem (crossing into new rows if needed). The coldata output will always be a 1xN vector using this form. Even if the column is a vector.

Example:

```
[ready]: handle = fits_open_file("C:/NXEROS_0001/XRS00053.FIT ","fits")
[ready]:coldata=fits_read_col_values(handle,col,firstrow,firselem,melem
)
```

fits_read_col_str — *Reads column strings*

Syntax: $coldstr **= fits_read_col_str**(handle, col, firstrow, firselem, melem) or

$coldstr = **fits_read_col_str**(handle, col, firstrow, num_rows) or

$coldstr = **fits_read_col_str(** handle, col **)**

Description: Reads the column values converted to strings starting with firstrow, firstelem, and continuing for nelem (crossing into new rows if needed). The coldata output will always be a 1xN vector using this form. Even if the column is a vector.

.

Example:

```
[ready]: handle = fits_open_file("C:/NXEROS_0001/XRS00053.FIT ","fits")
[ready]: colstr = fits_read_col_str(handle,col,firstrow,firselem,melem)
```

fits_read_subset — *Reads an image subregion*

Syntax: image **= fits_read_subset**(handle,) or

image = **fits_read_subset**(handle, ll_point, ur_point, step) or

Description: Reads an arbitrary subregion from the input FITS file. The optional parameters *ll_point* (lower-left corner point)*, ur_point* (upper-right corner point) and *step* (step increment values for each dimension) can be used to specify the subregion to read. If the optional parameters are not specified the entire image is read.

fits_write_subset — *Writes an image subregion*

Syntax: **fits_write_subset**(handle, data) or

fits_write_subset(handle, data, ll_point, ur_point) or

Description: Writes an arbitrary subregion to the FITS file. The optional parameters *ll_point* (lower-left corner point) and *ur_point* (upper-right corner point) can be used to specify the subregion where to write. If the optional parameters are not specified the entire image is written. Returns zero upon successful write.

fits_close_file — *Closes a FITS file*

Syntax: **status = fits_close_file(handle)**

Description: Closes a previously open fits file.

Example:

```
[ready]: status = fits_close_file(handle)  // handle = 1 ( from the
previous example )
[ready]: status
0
```

FLEVEL internal keyword to MSHELL

Syntax:

Description: internal keyword used by MSHELL

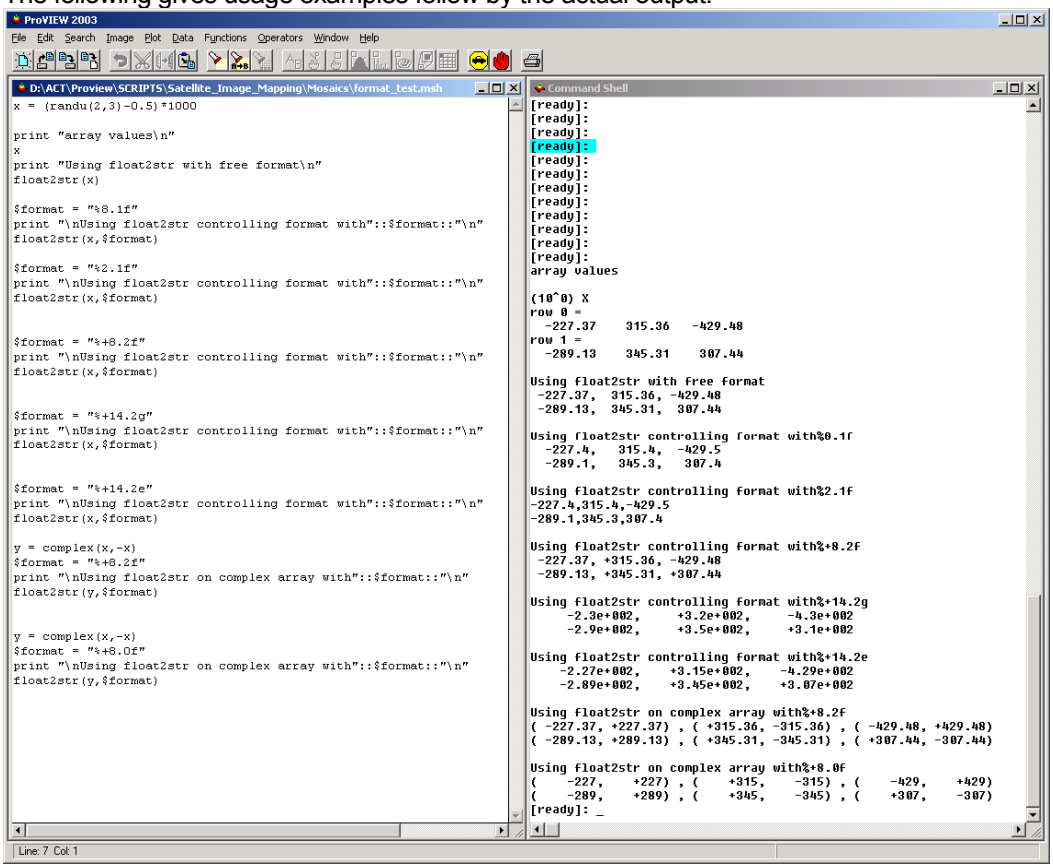
float2str Convert Array to a formatted String

Syntax: **float2str(a)** or **float2str(a,$format)**

Description: Converts the input array 'a' to a string representation. The user can control the format of each element by providing a controlling string, i.e. $format, which follows the standard C language approach. If the input is complex, the data will be displayed in groups of (x,y) or (real,imaginary).

Example

The following gives usage examples follow by the actual output.



```
x = (randu(2,3)-0.5)*1000
print "array values\n"
x
print "Using float2str with free format\n"
float2str(x)

$format = "%8.1f"
print "\nUsing float2str controlling format with"::$format::"\n"
float2str(x,$format)

$format = "%2.1f"
print "\nUsing float2str controlling format with"::$format::"\n"
float2str(x,$format)

$format = "%+8.2f"
print "\nUsing float2str controlling format with"::$format::"\n"
float2str(x,$format)

$format = "%+14.2g"
print "\nUsing float2str controlling format with"::$format::"\n"
float2str(x,$format)

$format = "%+14.2e"
print "\nUsing float2str controlling format with"::$format::"\n"
float2str(x,$format)

y = complex(x,-x)
$format = "%+8.2f"
print "\nUsing float2str on complex array with"::$format::"\n"
float2str(y,$format)

y = complex(x,-x)
$format = "%+8.0f"
print "\nUsing float2str on complex array with"::$format::"\n"
float2str(y,$format)
```

floor *Floor of Input Array*

Syntax: **floor**(a) or a.**floor**

Description: For each element in ‘a’ compute the largest integer not greater than that element, i.e. returns the Greatest Integer Value for each element of the array.

Example: The following illustrates the function.

```
[ready]: floor(3.3::4.5)
row 0 =
  3.0   4.0
```

fmod *Floating-Point Modulus*

Syntax: **fmod**(a,b)

Description: Compute the floating point modulus of every element in the input array.

Example: The following illustrates the function.

```
[ready]: a = (4,6,1)        // create row vector
[ready]: fmod(a+.5,3)
row 0 =
  1.50   2.50   0.50
```

free *Free Variable from Memory*

Syntax: **free** a b ... c

Description: Used to erase a list of already defined variables from memory; also have **free all**, **free** plot[#] plot[#] .... plot[#]. The variable list can contain array variables or string variables. To erase all variables from memory use **free all**. As you delete image variables the total memory available will increase. However, the amount of memory increase may not correspond directly to the size of the object just released. This is due to the fact that MSHELL can have two different variable names sharing the same array structure in memory as long as they have an identical content. To erase all of the variables in the current function's scope only, use **free local**.

ftp_cd — *Changes Current FTP Server Directory*

Syntax: **ftp_cd**($dirname)

Description: This function works after an ftp_session_init and changes the current working directory into the user specified one; ".." can be used to change to the parent directory. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

Example: see ftp_list example.

ftp_cwd — *Get Current FTP Server Directory*

Syntax: **ftp_cwd**()

Description: This function works after an ftp_session_init and can be used to retrieve the current FTP Server working directory as a string variable. If no connection is established with an FTP Server, it returns an empty string.

Example: see ftp_list example.

ftp_del — *Delete a File in the FTP Server*

Syntax: **ftp_del**($filename)

Description: This function works after an ftp_session_init and deletes the specified remote file in the FTP server. Multiple file names can be specified by separating them with new lines. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

ftp_get — *Download a File from the FTP Server*

Syntax: **ftp_get**($remotefile, $localfile)

Description: This function works after an ftp_session_init and downloads the specified remote file from the FTP server assigning the specified local file name to the local copy. Multiple file names can be specified by using new lines as file name delimiters. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

Example: see ftp_list example.

ftp_list — *List FTP Server Files and Subdirectories*

Syntax: **ftp_list**()

Description: This function works after an ftp_session_init and can be used to retrieve as a string variable the list of files and subdirectories of the current FTP Server directory. If no connection is established with an FTP Server, it returns an empty string.

Example: The following example shows most of the FTP functions being utilized on a simple test case.

```
// username and password are not required
// for connecting to the FTP server
s = ftp_session_init("ftp.csc.noaa.gov,21,,,")
// whenever the returned status is a non-zero value, an error occurs
if (s) {
                    s.text
                    return
}

// changing to a different directory
s = ftp_cd("incoming/ameredith/act")
if (s) {
                    s.text
                    return
}
print "Current directory is "::ftp_cwd()

// listing subdirectories and files of curtrent directory
ftp_list()

// downloading a file from the FTP server
print "Getting file 'gbrevecnts.txt'... "
s = ftp_get("gbrevecnts.txt", "local.txt")
if (s) {
                    s.text
                    return
}
print "done"

// closing FTP connection
s = ftp_session_close()
if (s) {
                    s.text
                    return
}
```

ftp_mkdir — *Create New Directory in the FTP Server*

Syntax: **ftp_mkdir**($newdir)

Description: This function works after an ftp_session_init and creates a new specified subdirectory in the FTP Server. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

ftp_put *Upload a File to the FTP Server*

Syntax: **ftp_put**($localfile, $remotefile)

Description: This function works after an ftp_session_init and uploads the specified local file to the FTP server assigning the specified remote file name to the remote copy. Multiple file names can be specified by using new lines as file name delimiters. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

ftp_rename *Rename a File in the FTP Server*

Syntax: **ftp_rename**($newfilename)

Description: This function works after an ftp_session_init and renames the specified file name in the FTP server. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

ftp_rmdir *Remove Directory from the FTP Server*

Syntax: **ftp_rmdir**($dirname)

Description: This function works after an ftp_session_init and removes the specified subdirectory from the FTP Server. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

ftp_session_close *Close Current FTP Session*

Syntax: **ftp_session_close**()

Description: Closes the current FTP session (if any was established). If successful, it returns 0, otherwise it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

Example: see ftp_list example.

ftp_session_init — *Open an FTP Session*

Syntax: **ftp_session_init**($params)

where,

$params = "host,port,username,password,timout"

Description: Opens an FTP session with the specified host name using the specified port number (if no port number is specified, port 21 will be used). "username" and "password" are optional if FTP server does not require them for logging in. An optional connect timeout in seconds could also be specified. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.
NOTE: THE ftp_... related functions are only supported in the version of MSHELL that runs under ACT's ACT-REACT.

Example: see ftp_list example.

- G -

gauss *N-Dimensional Gaussian Density*

Syntax: **gauss**(a,invcov,det)

Description: Given a covariance matrix, this function evaluates the Zero Mean Multi-Dimensional Gaussian Density Function. The gaussian density function is evaluated for each column vector in 'a'.

The actual mathematical expression evaluated for each column vector in 'a' is,

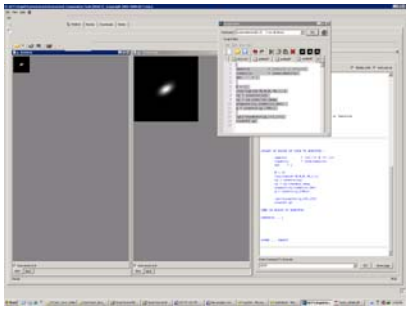
$$Zx_c = \frac{1}{\left[2\pi\right]^{N/2} \cdot \left|\Sigma\right|^{1/2}} \cdot \exp\left(\frac{1}{2} x_c^t \Sigma^{-1} x_c\right),$$

where: Σ is the covariance matrix of the Gaussian density function with dimensions N x N (N is the dimension of the columns in 'a'); x_c is a column vector in the input array (the function is evaluated for each column in 'x'); Σ^{-1} is the matrix inverse of the covariance matrix; and $\left|\Sigma\right|$ is the determinant of the covariance matrix.

The output of this function is a row vector of length equal to number of columns present in the input array 'a'.

Example:

```
cmatrix             = (18::7) # (7::11)
icmatrix            = invm(cmatrix)
det                 = 1

N = 32
[xy]=cgrid[-N,N,N,-N,1,1]
xy = convtov(xy)
xy = xy.real#xy.imag
g=gauss(xy,icmatrix,det)
g = convtoi(g,2*N+1)

[g2]=zoom2fit[g,256,256]
view255 g2
```



geclipto *Greater or Equal Clip to*

Syntax: **geclipto**(a,tval,newval)

Description: Set all the values in the input array greater than or equal to a selected threshold to a new desired value, where, 'a' is the input array, 'tval' is the threshold value, and 'newval' is the desired new value.

Example: The following illustrates the operation.

```
[ready]: x = (0,3,1)
x
row0 =
0.00   1.00   2.00   3.00
[ready]: y = geclipto(x,2,999)
  0.00   1.00 999.00 999.00
```

geindex *Greater than or Equal Index*

Syntax: **geindex**(a,b)

Description: Similar to **eqindex**, but it returns an index to all elements in 'a' greater or equal than 'b'.

Example: The following illustrates the operation.

```
[ready]: a = geo(-2,8)
[ready]: geindex(a,16)
row 0 =
  4.00-  0.00i   6.00-  0.00i
```

geo *Geometric Series*

Syntax: **geo**(a,n)

Description: Generates a vector whose elements are the first 'n' terms of the geometric series of the input scalar, 'a'. It is expected that 'a' be a real or complex scalar. Mathematically, **geo**(a,n) generates the row vector,

$$\begin{pmatrix} a^0 & a^1 & \cdots & a^{n-1} \end{pmatrix}$$

Example: The following illustrates the operation.

```
[ready]: geo(-2,8)
row 0 =
  1.00  -2.00   4.00  -8.00  16.00 -32.00  64.00 -128.00
```

Geo2Cart Geographic to Cartographic conversion

Syntax: out = Geo2Cart(llgrid,pcontrol)

Description: This function converts from geographic coordinates to cartographic coordinates and viceversa. There is a script function wrapper called geo2cart[] that simplifies the usage to this function. This function is used extensively by MSHELL to generate cartographic products.

The inputs to this MSHELL function are:

llgrid –complex array with latitude (imaginary part) and longitude values in degrees.

pcontrol – used to control the cartographic projection as described in the USGS projection software. Use pcontrol=1 for forward projection (from geographic to cartographic), or -1 for inverse projection. Pcontrol.text contains all the detail controlling parameters for the mapping transformation. It follows the USGS Cartographic Projection Program syntax, see Appendix D: Cartographic Library for syntax details.

The output is:

out - complex array with corresponding carthographic values. Real part has x-component, and imaginary part has y-component.

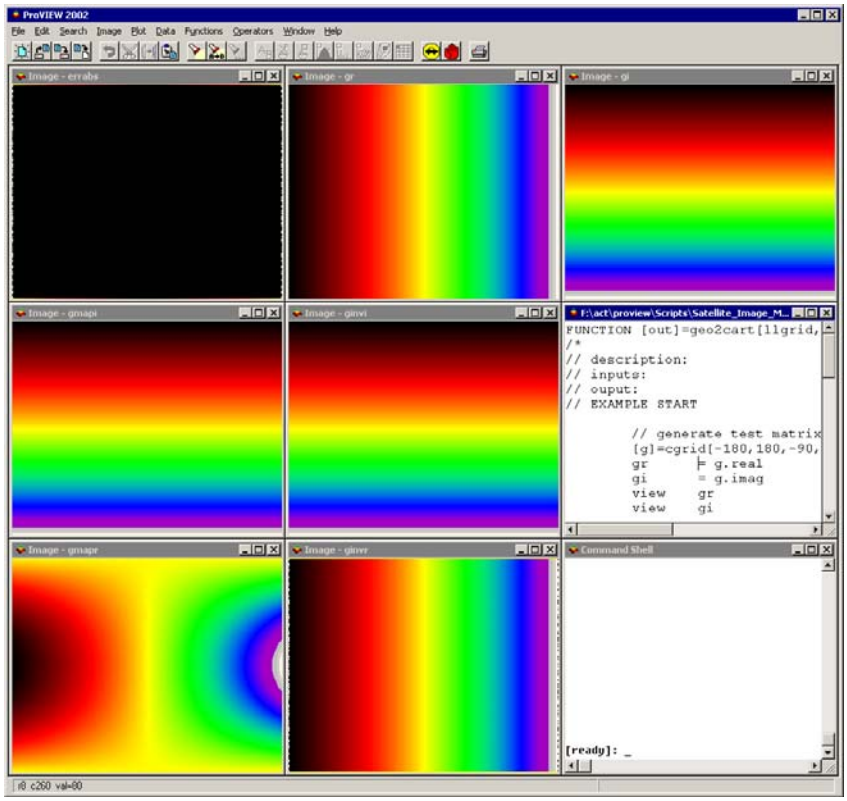
Note: Geo2Cart, makes direct use of a DLL based on the Cartographic Projection Program (developed by U.S. Geological Survey) version 4.4.3,

See *Cartographic Projection Procedures for the UNIX Environment---A User's Manual,* (Evenden, 1990, Open-file report 90-284).
A web reference can be found at: **http://www.remotesensing.org/proj/**

See Also: geo_cs2cs().
Some of the function using this Geo2Cart and geo_cs2cs() are: dworld(), and MI_geo2cart.msf, Map_Image.msf, …

Example: This function can also be accessed using the external function script called '**geo2cart.msf'**. This script acts as a trivial wrapper around Geo2Cart.

```
// EXAMPLE START
// generate test matrix of geographic data points
                  [g]=cgrid[-180,180,-90,90,1,1]
                  gr  = g.real
                  gi  = g.imag
                  view    gr
                  view    gi
                  wtile

// construct controlling parameters for the mapping transformation
                  $LF     = "\n"
                  $control    = "proj=sinu"       ::$LF::     \\
                            "ellps=clrk66"    ::$LF::     \\
                            "lat_0=00"        ::$LF::     \\
                            "lon_0=00"        ::$LF::     \\
                            "no_defs"
                  cntl        = 1 // forward transformation
                  cntl.text       = $control
                  [gmap]      = geo2cart[g,cntl]
                  gmapr       = gmap.real
                  gmapi       = gmap.imag
                  view gmapr
                  view gmapi

                  cntl        = -1    // inverse transformation
                  cntl.text   = $control
                  [ginv]      = geo2cart[gmap,cntl]
                  ginvr       = ginv.real
                  ginvi       = ginv.imag
                  view    ginvr
                  view    ginvi
                  errabs  = abs(g-ginv)

                  view    errabs
                  wtile
// EXAMPLE END
```



There are a large number of projections supported by Geo2Cart. A list of projections can be obtained from the following command:

```
$cmds = "proj -l "
[result]=syscall[$cmds]
result.text
```

i.e.,

aea	:AlbersEqualArea	fouc	:Foucaut
aeqd	:AzimuthalEquidistant	fouc_s	:FoucautSinusoidal
airy	:Airy	gall	:Gall(GallStereographic)
aitoff	:Aitoff	gins8	:GinsburgVIII(TsNIIGAiK)
alsk	:Mod.StererographicsofAlaska	gn_sinu	:GeneralSinusoidalSeries
apian	:ApianGlobularI	gnom	:Gnomonic
august	:AugustEpicycloidal	goode	:GoodeHomolosine
bacon	:BaconGlobular	gs48	:Mod.Stererographicsof48U.S.
bipc	:Bipolarconicofwesternhemisphere	gs50	:Mod.Stererographicsof50U.S.
boggs	:BoggsEumorphic	hammer	:Hammer&Eckert-Greifendorff
bonne	:Bonne(Wernerlat_1=90)	hatano	:HatanoAsymmetricalEqualArea
cass	:Cassini	imw_p	:InternationalMapoftheWorldPolyco
cc	:CentralCylindrical	nic	
cea	:EqualAreaCylindrical	kav5	:KavraiskyV
chamb	:ChamberlinTrimetric	kav7	:KavraiskyVII
collg	:Collignon	labrd	:Laborde
crast	:CrasterParabolic(PutninsP4)	laea	:LambertAzimuthalEqualArea
denoy	:DenoyerSemi-Elliptical	lagrng	:Lagrange
eck1	:EckertI	larr	:Larrivee
eck2	:EckertII	lask	:Laskowski
eck3	:EckertIII	latlong	:Lat/long(Geodetic)
eck4	:EckertIV	longlat	:Lat/long(Geodetic)
eck5	:EckertV	lcc	:LambertConformalConic
eck6	:EckertVI	leac	:LambertEqualAreaConic
eqc	:EquidistantCylindrical(PlateCaree)	lee_os	:LeeOblatedStereographic
eqdc	:EquidistantConic	loxim	:Loximuthal
euler	:Euler	lsat	:SpaceobliqueforLANDSAT
fahey	:Fahey		

mbt_s	:McBryde-ThomasFlat-PolarSine(No.1)
mbt_fps	:McBryde-ThomasFlat-PoleSine(No.2)
mbtfpp	:McBride-ThomasFlat-PolarParabolic
mbtfpq	:McBryde-ThomasFlat-PolarQuartic
mbtfps	:McBryde-ThomasFlat-PolarSinusoidal
merc	:Mercator
mil_os	:MillerOblatedStereographic
mill	:MillerCylindrical
mpoly	:ModifiedPolyconic
moll	:Mollweide
murd1	:MurdochI
murd2	:MurdochII
murd3	:MurdochIII
nell	:Nell
nell_h	:Nell-Hammer
nicol	:NicolosiGlobular
nsper	:Near-sidedperspective
nzmg	:NewZealandMapGrid
ob_tran	:GeneralObliqueTransformation
ocea	:ObliqueCylindricalEqualArea
oea	:OblatedEqualArea
omerc	:ObliqueMercator
ortel	:OrteliusOval
ortho	:Orthographic
pconic	:PerspectiveConic
poly	:Polyconic(American)
putp1	:PutninsP1
putp2	:PutninsP2
putp3	:PutninsP3
putp3p	:PutninsP3'
putp4p	:PutninsP4'
putp5	:PutninsP5
putp5p	:PutninsP5'
putp6	:PutninsP6
putp6p	:PutninsP6'
qua_aut	:QuarticAuthalic
robin	:Robinson
rpoly	:RectangularPolyconic
sinu	:Sinusoidal(Sanson-Flamsteed)
somerc	:Swiss.Obl.Mercator
stere	:Stereographic
tcc	:TransverseCentralCylindrical
tcea	:TransverseCylindricalEqualArea
tissot	:Tissot
tmerc	:TransverseMercator
tpeqd	:TwoPointEquidistant
tpers	:Tiltedperspective
ups	:UniversalPolarStereographic
urm5	:UrmaevV
urmfps	:UrmaevFlat-PolarSinusoidal
utm	:UniversalTransverseMercator(UTM)
vandg	:vanderGrinten(I)
vandg2	:vanderGrintenII
vandg3	:vanderGrintenIII
vandg4	:vanderGrintenIV
vitk1	:VitkovskyI
wag1	:WagnerI(KavraiskyVI)
wag2	:WagnerII
wag3	:WagnerIII
wag4	:WagnerIV
wag5	:WagnerV
wag6	:WagnerVI
wag7	:WagnerVII
weren	:WerenskioldI
wink1	:WinkelI
wink2	:WinkelII
wintri	:WinkelTripel

For additional details on each projection see page 345.

geo_cs2cs geo coordinate system transformation

Syntax: out = geo_cs2cs (proj4IN,proj4OUT,xy,direction)

Description: This function converts from the input array 'xy' from one coordinate system to another. The coordinate system must be provided by proper PROJ4 string.

proj4IN - scalar with text attribute set to the projection string that describes the input

proj4OUT - scalar with text attribute set to the projection string that describes the input

direction – if direction=1 ➔ forward transformation, i.e IN to OUT, otherwise it will perform OUT to IN

xy - input coordinate values. Real part has x-component, and imaginary part has y-component. The units of xy most be consistent with the units of the projection space that it represents.

out - output array with transformed values

Note: see also Geo2Cart()

GeoXform_RCtoXY Transform from RC to XY coordinates.

Syntax: **out = GeoXform_RCtoXY (geoxform_v, IN, direction, integerRC)**

Description: This function converts the input array *IN* from RC to XY coordinates and viceversa using the geoxform vector as returned by the gdal_get_geo_transform.

direction – if direction=1 ➔ the conversion is from RC to XY, otherwise the conversion is from XY to RC. In the latter case you can specify with *integerRC* whether computed RC indexes should be integer numbers.

geo_get_datums_list Return the list of datums supported

Syntax: **geo_get_datums_list()**

Description: Returns the list of datums supported by PROJ4 lib.

See Also: geo_get_ellipdoids_list, geo_get_projections_list

geo_get_ellipsoids_list Return the list of ellipsoids supported

Syntax: **geo_get_ellipsoids_list()**

Description: Returns the list of ellipsoids supported by PROJ4 lib.

See Also: geo_get_datums_list, geo_get_projections_list

geo_get_proj_info Return the current PROJ4 version

Syntax: **geo_get_proj_info()**

Description: Returns the current PROJ4 version as a string.

geo_get_projections_list Return the list of projections supported

Syntax: **geo_get_projections_list()**

Description: Returns the list of projections supported by PROJ4 lib.

See Also: geo_get_datums_list, geo_get_ellipsoids_list

get_finite_subarray Returns a subarray with all elements finite

Syntax: **get_finite_subarray**(a, wsize)

Description: Returns a subarray of the specified size where all contiguous elements in the source array are finite. wsize is a row vector specifying the number of rows and columns of the subarray in the form rows::cols. If no subarray with finite elements is found then a null array is returned.

getenv Get Environment Variable

Syntax: **getenv**($string)

Description: Returns a string which is the currently held value for the $string passed in parenthesis. This $string is the environment variable for which information is to be retreived.

```
[ready]: getenv("PATH")
C:\WINNT40\SYSTEM32;
```

getline Finds Line Matching String Pattern

Syntax: **getline**($str,$pattern)

Description: Given a string variable, $str, this function can be used to find the line where the string $pattern appears for the first time.

Example: The following example illustrates the function.

```
[ready]: $a = "Now \n is the \n time \n for all..."
[ready]: $a
Now
 is the
 time
 for all...
[ready]: line = getline($a,"time")
[ready]: $b = $a(line,:)
[ready]: $b
 time
```

See Also: eqindexS(), getpos(), .

getMyIP Get the local IP addresses

Syntax: **getMyIP**()

Description: This function can be used to retrieve the local IP addresses as a new line delimited string variable.
NOTE: This function is only supported in the version of MSHELL that runs under ACT's ACT-REACT.

Example: The following example illustrates the function.

```
[ready]: $ip = getMyIP()
[ready]: $ip
192.168.0.1
212.48.10.150
```

get_host_addresses Return the list of IP addresses of the specified host

Syntax: **get_host_addresses**($host_name)

Description: Return the list of IP addresses of the specified host *$host_name*. If $host_name is an empty string the local host IP addresses are returned.

getpos Finds String Position Within a Line

Syntax: **getpos**($str,$pattern)

Description: Given a string variable, $str, this function can be used to find the position within a *line where the string $pattern appears for the first time.*

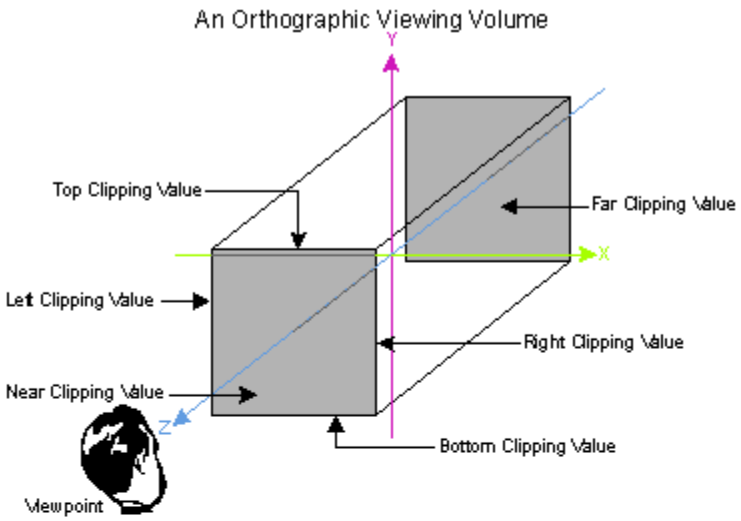
Example: The following example illustrates the function.

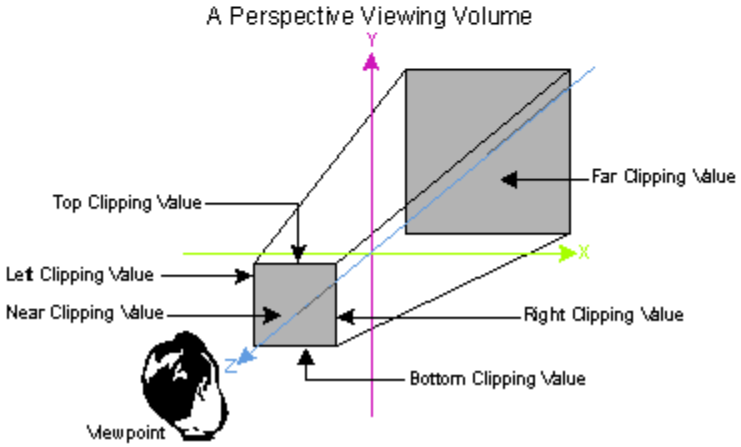
```
[ready]: $a = "Now \n is the \n time \n for all..."
[ready]:$b = $a(2,:)
[ready]:$b
 time
[ready]: getpos($b,"i")
   2
[ready]: getpos($b,"e")
    4
```

glflyover generate perspective view of terrrain

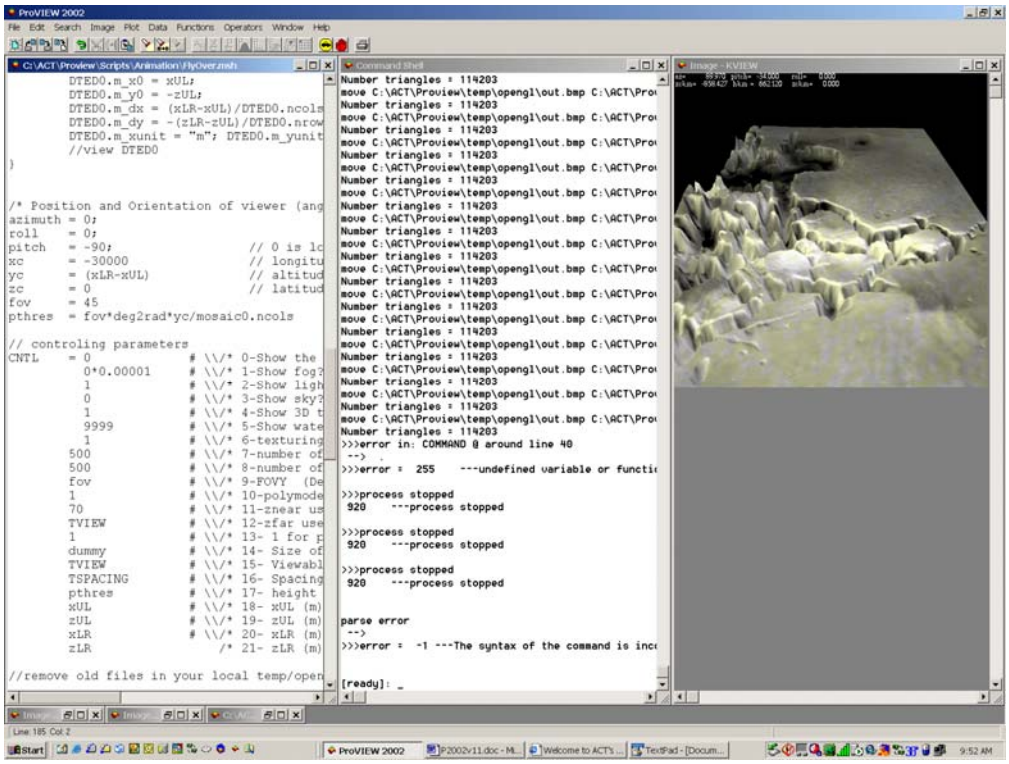
Syntax: **glflyover(DTED,mosaic,CNTL,dummy,PandO)**

Description: Generates a perspective view of an image (mosaic) using input terrain elevation (DTED). This functions can be better understood by looking at the 'flyover.msh' script file. This function is implemented using OpenGL's implementation under the respective OS. The coordinate system used is depicted below


An Orthographic Viewing Volume
Y
X
Z
Top Clipping Value
Far Clipping Value
Left Clipping Value
Right Clipping Value
Near Clipping Value
Bottom Clipping Value
Viewpoint


A Perspective Viewing Volume
Y
X
Z
Top Clipping Value
Far Clipping Value
Left Clipping Value
Near Clipping Value
Right Clipping Value
Bottom Clipping Value
Viewpoint

Example:


ProVIEW 2002
File Edit Search Image Plot Data Functions Operators Window Help
C:\ACT\Proview\Scripts\Animation\FlyOver.msh
DTED0.m_x0 = xUL;
DTED0.m_y0 = -zUL;
DTED0.m_dx = (xLR-xUL)/DTED0.ncols
DTED0.m_dy = -(zLR-zUL)/DTED0.nrow
DTED0.m_xunit = "m"; DTED0.m_yunit
//view DTED0
}
/* Position and Orientation of viewer (ang
azimuth = 0;
roll = 0;
pitch = -90; // 0 is lo
xc = -30000 // longitu
yc = (xLR-xUL) // altitud
zc = 0 // latitud
fov = 45
pthres = fov*deg2rad*yc/mosaic0.ncols
// controling parameters
CNTL = 0 # \\/* 0-Show the
0*0.00001 # \\/* 1-Show fog?
1 # \\/* 2-Show ligh
0 # \\/* 3-Show sky?
1 # \\/* 4-Show 3D t
9999 # \\/* 5-Show wate
1 # \\/* 6-texturing
500 # \\/* 7-number of
500 # \\/* 8-number of
fov # \\/* 9-FOVY (De
1 # \\/* 10-polymode
70 # \\/* 11-znear us
TVIEW # \\/* 12-zfar use
1 # \\/* 13- 1 for p
dummy # \\/* 14- Size of
TVIEW # \\/* 15- Viewabl
TSPACING # \\/* 16- Spacing
pthres # \\/* 17- height
xUL # \\/* 18- xUL (m)
zUL # \\/* 19- zUL (m)
xLR # \\/* 20- xLR (m)
zLR /* 21- zLR (m)
//remove old files in your local temp/open
Command Shell
Number triangles = 114203
move C:\ACT\Proview\temp\opengl\out.bmp C:\ACT\Pro
>>>error in: COMMAND @ around line 40
>>>error = 255 ---undefined variable or functi
>>>process stopped
920 ---process stopped
parse error
>>>error = -1 ---The syntax of the command is inc
[ready]: _
Image - KVIEW
Start
ProVIEW 2002
9:52 AM

gmtimenow current GMT time

Syntax: **gmtimenow()**

Description: Returns the GreenWich mean time.
Columns 0-5 correspond to year,month,day,hour,minute,second. Column 6 is the day of the week (Sunday=0). Column 7 is the Julian day. If x=gmtimenow(), then x.text will have a nicely formatted time string.

Example:

```
t = gmtimenow()
t

(10^0) X
row 0 =
  2004.00  7.00   8.00  14.00  45.00  53.33   4.00 190.00   0.00

t.text
2004-07-08T14:45:53.328
```

gravity_potential Calculate the planet gravity potential

Syntax: gp = **gravity_potential**(GM, Re, C, S, F, radius, lon, lat)

Description: Calculate the planet (based on a sphere model given by the *radius*) gravitity potential at the specified polar coordinate *(lon, lat, radius)*. The other parameters are:

- GM: the gravitational constant times the mass of the planet
- Re: reference planet radius
- C, S: normalized coefficients
- F: associated Legendre polynomial normalization coefficients, such that:

$$\overline{P}_n^m(x) = F_n^m P_n^m(x)$$

where $\overline{P}$ is the fully normalized associated Legendre polynomials, *P* is the associated Legendre polynomials and *F* is the normalization coefficients given by:

$$F_n^m = \sqrt{k(2n+1)\frac{(n-m)!}{(n+m)!}}$$

where $k = \begin{cases} 1 & m = 0 \\ 2 & 0 < m \le n \end{cases}$

gtclipto Greater than Clip to

Syntax: **gtclipto**(a,tval,newval)

Description: Set all the values in the input array above a selected threshold to a new desired value, where 'a' is the input array, 'tval' is the threshold value, and 'newval' is the desired new value.

Example: The following illustrates the operation.

```
[ready]: x = (0,3,1)
x
row0 =
0.00   1.00   2.00   3.00
[ready]: y = gtclipto(x,2,999)
  0.00   1.00 2.00  999.00
```

gtindex Greater than Index

Syntax: **gtindex**(a,b)

Description: Similar to **eqindex**, but it returns an index to all elements in 'a' greater than 'b'.

Example: The following illustrates the operation.

```
[ready]: a = geo(-2,8)
[ready]: a
  1.00  -2.00   4.00  -8.00  16.00 -32.00  64.00 -128.00
[ready]: gtindex(a,8)
  4  + 0i   6 + 0i
```

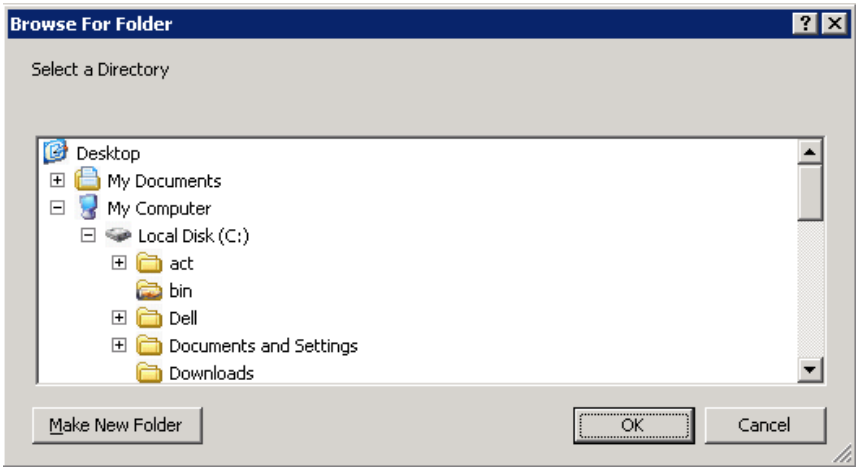
gui_getdir Open a GUI directory browser dialog

Syntax: **gui_getdir**($initial_dir)

Description: This function opens a GUI directory browser dialog and returns the path selected by the user. The optional input argument can be used as the initial directory for the GUI dialog.

Example: The following command will open the a dialog box for the user.

$mydir= gui_getdir("c:/temp")



gui_getfile — *Open a GUI file browser dialog*

Syntax: **gui_getfile**($initial_dir)

Description: This function opens a GUI file browser dialog and returns the absolute path to the file selected by the user. The optional input argument can be used as the initial directory for the GUI dialog.

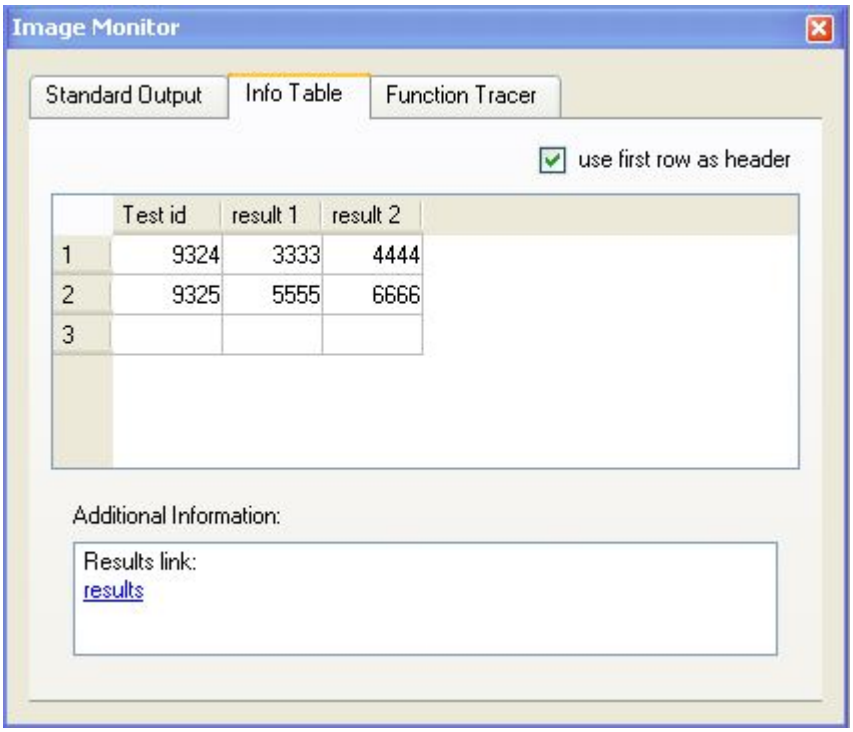
guiInfoTable — *Populate the info table in REACT Monitoring Panel*

Syntax: **guiInfoTable**($csvInfo, $additionalInfo)

Description: This function allows to populate the info table in REACT Monitoring Panel. The list of cell values is passed in csv format through *$csvInfo* parameter: each line in *$csvInfo* is interpreted as a new record and each record element needs to be separated by a comma. *$additionalInfo* contains additional information that are displayed below the table. *$additionalInfo* can contain HTML tags.

Example: The following illustrates a simple example for this command.

```
$strHeader = "Test id,result 1,result 2\n"
$strRecord1 = "9324,3333,4444\n"
$strRecord2 = "9325,5555,6666"

$csvInfo = $strHeader::$strRecord1::$strRecord2
$addInfoMsg="Results link:<br><a href='http://www.mypage.com'>results</a>"

guiInfoTable($csvInfo, $addInfoMsg)
```



- H-

hammiw *Hamming Window*

Syntax: **hammiw**(n [,m])

Description: Generates a 1-D or 2-D Hamming Window, where the *n*th element in the Hamming Window, is defined as,

$$w_n = 0.54 - 0.46\cos(\frac{2\pi}{N} \cdot n), \quad n = 0,1,2,\ldots N-1$$

This window has side lobes in the frequency domain of -43dB. Note, the Hamming Window is a special case of the Blackman-Harris Window. The syntax for generation of a row vector containing the 1-D, n element Hamming Window is, **hammiw**(n), and the syntax for generating the 2-D n x m element Hamming Window is, **hammiw**(n,m). This 2-D array is equivalent to the MSHELL construction:

```
hammiw(n)' * hammiw(m)
```

Example: Let 'a' be an array with dimensions that are a power of two. The following MSHELL command will multiply the array 'a' with a 2-D Hamming Window, followed by the 2-D FFT,

```
fft2(hammiw(nrows(a), ncols(a)) *. a)
```

help *Invokes the Help Utility*

Syntax: **help** [topic]

Description: You can invoke the help utility directly from the command line. An optional topic argument can be provided to search for help on that topic. If the *topic* string contains an ending '*' character, the **help** command will prompt all MSHELL commands that starts with *topic* string.

Example: For help on the **cos** function, type from the command line:

```
help cos
```

To prompt the list of MSHELL GDAL commands:

```
help gdal*
```

heqlut *Histogram Equalization LUT*

Syntax: **heqlut**(a) or a.**heqlut**

Description: Computes the 256 entry (8 bit) look-up-table (or intensity transformation) which when applied to the input image, 'a', will result in a more uniform distribution of intensity value.

Example: An image x can be subjected to the heqlut intensity transformation, prior to display, using the following MSHELL instructions,

```
wcolut3 = ones(1,3)*heqlut(X)
select wcolut3;
```

Note that selecting wcolut3 does not change the content of the actual image in memory, only the way that it is displayed.

---

hist *Histogram Generator*

Syntax: **hist**(a,amin,amax,n)

Description: This is a general purpose histogram generation subroutine. It performs a histogram value of the element in the source input array. The elements on the input array are first transformed by a linear equation which determines the range of the data to histogram, and the number of bins on that range, where 'a' is the input array, 'amin' and 'amax' are the extreme values, and 'n' is the number of levels over which the input will be grouped. This function is particularly useful with floating point data, while "**hist255**", below, is optimized for integer data in the range of 0 to 255.

---

hist255 *Histogram of 8 bit data*

Syntax: **hist255**(a) or a.**hist255**

Description: Generate a histogram of the distribution of intensity values in the input array. **The data values within the input array must assume only integer values in the range of 0 to 255 inclusive**. The returned vector has 256 entries; where a k positive value in the i^{th} -1 entry implies there were k elements in the input array which assumed the i^{th} value.

Example: The following is a typical application.

```
[ready]:x = reada("eqohare.chr","char");
[ready]: plot(hist255(x))
```

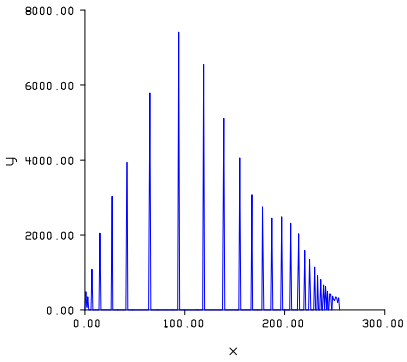


Figure 3

---

hyplut *Hyperbolic Histogram LUT*

Syntax: **hyplut**(a,imin,imax)

Description: Computes the 256 entries (8bit) look-up-table (or intensity transformation) which when applied to the input image will result in a hyperbolic distribution of intensity values. The input arguments are: the input image, 'a' and the intensity limits 'imin' and 'imax' , respectively, the minimum and the maximum values that any intensity value in 'a' can be map to. Both 'imin' and 'imax' must be between 0 and 255 inclusive. It is expected that the input image is representative of an image with 8 bits/pixel.

An advantage of using a hyperbolic lut is that it accounts for the assumed logarithmic or cube root response of the photoreceptors of the human eye model, resulting in a perceived more uniform distribution of intensity values. The actual intensity mapping utilized has the following mathematical representation:

$$hyplut(k) = i_{\min} \cdot \left(\frac{k_{\max}}{k_{\min}} \right)^{\sum_{j=0}^{K} P_a(j)}$$

$P_a(j)$ = hist255(a)/(a.nrows*a.ncols)

- I -

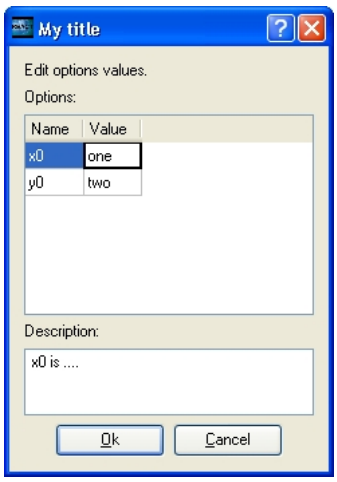
iboxlist *Input Box List*

Syntax: **iboxlist**($title,nitems,$ilist)

Description: This function is used to create an input box on the screen based on an input list of options. It allows the user to modify options in a form that is displayed on the screen. The dialog title is set to *$title*. *$ilist* contains the list of options parameters separated by "|" symbol. The first option parameter is the option name, the second option parameter is the option description the third option parameter is the option value and so on. *nitems* is the number of rows of the input box. If it is -1 then the number of rows will be automatically computed. The function returns a list of strings representing the list of values in the input box.

Example: the following illustrates how this function can be used

```
$title =  "My title"
$ilist = ""         //initialize input list

$item = "x0"
$itemdesc = "x0 is .... "
$itemval  = "one"
[list] = add2list[$ilist,$item,$itemdesc,$itemval]
$ilist = list.text

$item = "y0"
$itemdesc = "y0 is related to ...."
$itemval  = "two"
[list] = add2list[$ilist,$item,$itemdesc,$itemval]
$ilist = list.text

$list = iboxlist($title,2,$ilist)
```



idct8x8 Inverse Discrete Cosine Transform

Syntax: **idct8x8**(b)

Description: Used to perform the inverse discrete cosine transform on an array "b" which is the DCT of a previous function. The resultant will be identical to the original array previous to the creation of "b", except for small errors resulting from computer round off errors.

ident Generate an Identity Array

Syntax: **ident**(n)

Description: Create an N x N array in memory in which the main diagonal elements are set to value **+1** and all off diagonal elements are set to zero.

Example: The following MSHELL statement will create a 4x4 identity array in memory,

```
[ready]: ident(4)
row 0 =
   1.00    0.00    0.00    0.00
row 1 =
   0.00    1.00    0.00    0.00
row 2 =
   0.00    0.00    1.00    0.00
row 3 =
   0.00    0.00    0.00    1.00
```

IF-ELSE *IF-ELSE Conditionals*

Syntax: ***if****(expression){*

statements

}

or

if*(expression){*

statements

}else{

statements

}

Description: This condition is used to execute the statements if the expression is considered true.

ifft *Inverse 1-D FFT*

Syntax: **ifft**(a) or a.**ifft**

Description: Compute the one dimensional inverse Fourier transform of the input array. It is expected that the row dimension of the input array is a power of two. Note that the output of this operation is a complex array.

ifft2 *Inverse 2-D FFT*

Syntax: **ifft2**(a) or a.**ifft2**

Description: Compute the two dimensional inverse Fourier transform of the input array. It is expected that the dimensions of the input array are powers of two. Note that the output of this operation is a complex array.

imag *Imaginary Part*

Syntax: **imag**(a) or a.**imag**

Description: For a complex input array, extract the imaginary part for each element in the array.

Example: The following MSHELL statement will extract the imaginary part of the 2D Fourier Transform of 'a', and store the result in 'c',

```
[ready]: c = imag( fft2(a) )
```

image_outer_contour *Return image outer contour*

Syntax: contour = **image_outer_contour**(image, no_data_value[, opt])

Description: Finds the outer contour of the input image. 'no_data_value' is a scalar specifying the no valid values in the input image. 'opt' is a scalar optional parameter specifying the type of contour detection algorithm to use: it can be 0 for more accurate algorithm (slower and requiring more memory) or 1 for a less accurate (faster) algorithm. The faster version of the contour detection could return a wrong result if the image contour is very thin in some points (1-2 pixels wide). If 'opt' is not defined then the more accurate version of the contour detection is used (opt = 0).

Returns a row complex vector, whose array elements contain the coordinates of each contour point encoded as follows: the real part contains the column index and the imagery part contains the row index of the point. In case the image is made up by multiple groups of valid values (blobs) then the contour of the first valid blob found is returned. If no contour is found then the command returns a NULL array.

See Also: img2contour

image2surface *project planar image onto a surface*

Syntax: **image2surface**(image,xy,z,cntl1,cntl2,cntl3)

Description: Given an input 'image' defined over a rectangular grid, this command will drape the input image intensities on a surface grid defined by xy&z.
Note: This function is **primarily used** in MSHELL to go from sensor projection or sersor-scan into a cartographic map representation when a dense rectangular grid of ground control points is available, (in this case z is set to a constant value of zero and cntl3=0).

image	Real array with amplitude values for the image
xy	xy = complex (x,y) with values to be used for the projection. The number of rows and columns in xy must match the dimensions of image. If set to the zero scalar, a rectangular grid of xy, with monotonically increasing values, will be internally generated.
z	Real array with height values to be used in the projection. The number of rows and columns in xy **must** match the dimensions of image.
cntl1	**cntl1=ns::outrows::outcols::non_valid_pixel::background_level** Where, **ns=**1,…8 used to control the sampling of the input xyz grid. ns=1 is most accurate and ns=8 is the least accurate. **outrows** – is the number of rows in the desired output image **outcols** – is the number of columns in the desired output image **non_valid_pixel** – amplitude value used to specify a pixel with no data in 'image'. Such pixels will not be used in the projection **background_level** – initialize output image to this value, before starting the projection process
cntl2	Cntl2 = 0 ➔ compute range of min and max values internally Cntl2 = xmin::xmax::ymin::ymax::zmin::zmax force the use of the provided range of min and max values.
cntl3	Cntl3 = 0 ➔ to map input image into a planar grid with not additional rotation or tilt transormations or cntl3 = rot::tilt::show_base_image::show_borders for orthographic projections where, rot – is rotation of the input image in degrees tilt – is a rotation of the input image away from the normal show_base_image and show_borders must be set to zero. If this option of cntl3 is used, then cntl2 is set to 0 automatically.

See also:
Map_Image[ ], Map_Images[ ], MI_geo2cart[], … - these are external functions that supports intensity mapping from geographic to cartographic.

Example: The following example illustrates the function.

```
// Example1: illustrate image2surface with different sampling parameters
truth  = reada("eqohare.chr","char")// generate test sensor projection image
[truth]=zoom2fit[truth,300,300]
image0  = truth
view truth
[xy0]   =cgrid[0,image0.ncols-1,0,image0.nrows-1,1,1]
x0      = xy0.real
y0      = xy0.imag
k       =5
[xsp]=spiral[x0,k/10*3]
```

```
[ysp]=spiral[y0,k/10*3]
[isp]=spiral[image0,k/10*3]
view    xsp; view ysp; view    isp
wtile

// now apply image2surface, while changing  xy-sampling
image0  = isp

j       = sqrt(-1)
xy      = xsp+j*ysp

z       = zeros(image0.nrows,image0.ncols)*0
non_valid_pixel=0
groi    = eqindex(isp,non_valid_pixel)
backg   = 0
i       =75
while(i>1){
        xlev    = (0,x0.max-1,i)
        ylev    = (0,y0.max-1,i)
        backg   = 0
        [grid]  = DispContours[xy0,xlev,ylev,backg]
        dummy   = image0

        groi2   = index(grid)
        dummy(groi2)=128
        dummy(groi) = non_valid_pixel
        image   = dummy

        view image
        ns      =i
        print "ns = "::int2str(ns)::"\n"
        outrows =grid.nrows
        outcols =grid.ncols

        cntl1   =ns::outrows::outcols::non_valid_pixel::backg
        cntl3   =0
        cntl2   =0
        $ts = M_time
        image(wdef(nint(xsp.nrows/2/i)*i,nint(xsp.ncols/2/i)*i,i,i))=255
        outg    = image2surface(image,xy,z,cntl1,cntl2,cntl3)
        out0    = image2surface(image0,xy,z,cntl1,cntl2,cntl3)
        $te = M_time
        $ts::$te
        view  outg;    view  out0
        wtile
        i = i-3
}
```

```
// EXAMPLE 2:  reading read lunar topography from Clementine data
luntopo = reada("luntopo.flt","float")
B = luntopo.scale255    // set texture image to topography
view B
luntopo              = scale255(luntopo)
view luntopo
cntl1               =ns::outrows::outcols::non_valid_pixel::backg
cntl2               =0
cntl3               =30::40::0::1
moonTopo = image2surface(B,0,luntopo/2,cntl1,cntl2,cntl3)
view255 moonTopo
```

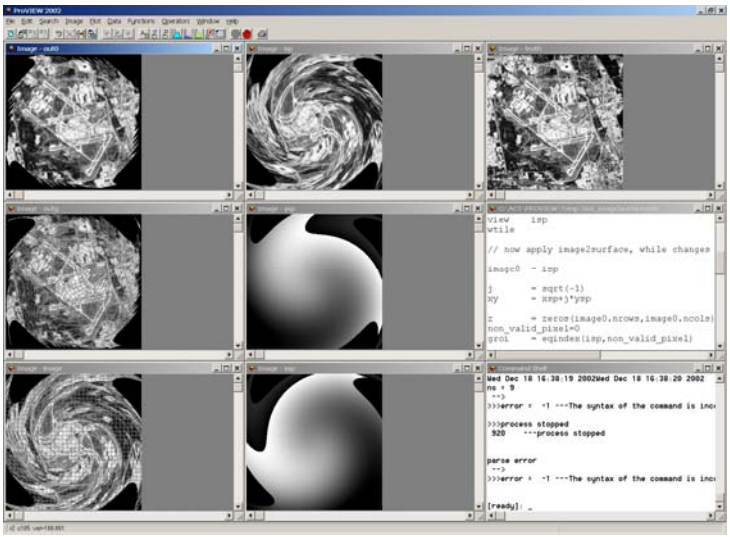


Figure 8 Example #1 output

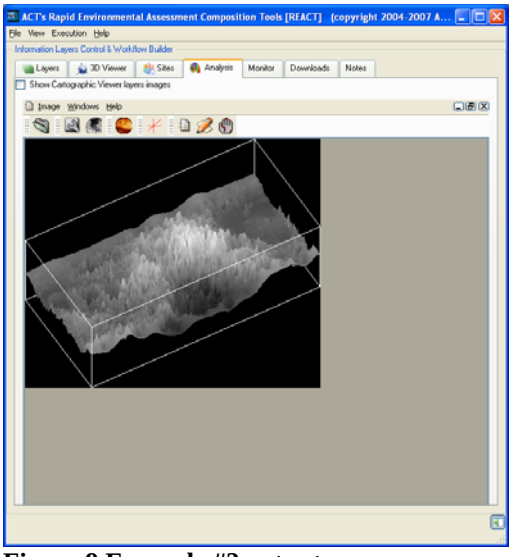


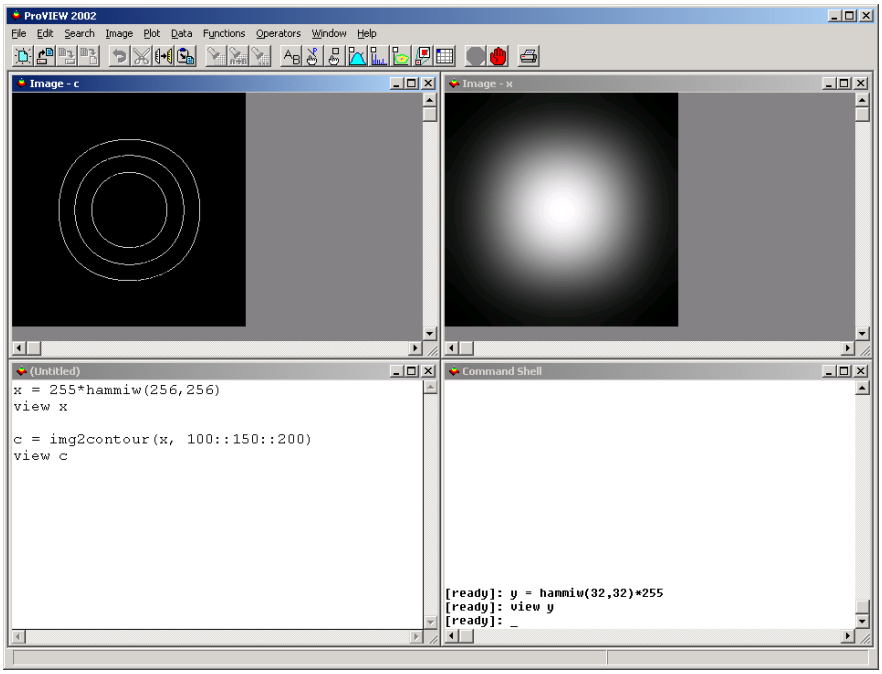
Figure 9 Example #2 output

img2contour *Create a contour image*

Syntax: **img2contour**(image, levels # graylevel)

Description: Generates an output contour from the input image. The levels are a row vector describing the contour steps desired, and the graylevel is a row vector describing the value to use when drawing the contour line.

See Also: image_outer_contour



include *Invoke an MSHELL Script File*

Syntax: **include** "fname"

Description: A file with a sequence of MSHELL commands can be invoked at any time through the use of the include command, where “fname” is the name of the script file to be executed.

Example: Given an MSHELL script file named ‘test.msh’, the MSHELL instructions contained in the file can be executed by simply typing: **include** "test" or **include** "test.msh".

In the first case above, the extension ".msh" was not included in the argument. In that case MSHELL will try to open the file ‘test’, if that fails it will try again after adding the extension ‘.msh’. The system variable M_path establishes which directories, in addition to the present directory, are to be searched.

index *Index of Non-Zero Elements*

Syntax: **index**(a,b)

Description: Similar to **eqindex**, but it returns an index to all elements different than zero.

Example: The following illustrates the indexing.

```
[ready]: a = (-2,2,2,2)
row 0 =
 -2.00   0.00   2.00
row 1 =
 -2.00   0.00   2.00
[ready]: index(a)
row 0 =
  0.00 -0.00i    2.00 -0.00i    0.00 +1.00i    2.00 +1.00i
```

input *waits user input*

Syntax: **input** a

Description: Pauses for input from console (does not work in GUI, only console MSHELL), then assigns the input value to string or array variable.

inputbox *Prompt User for Input*

Syntax: **inputbox**($prompt, $title, $default)

Description: Prompts for input through a dialog box, where all the input arguments are strings. This function returns a string which can be convert to a number. **See Also:** **str2int** and **str2float**

Example: The following illustrates the instructions and the Dialog Box.

```
[ready]: inputbox( "enter new value", "INPUT MENU", "1")
```

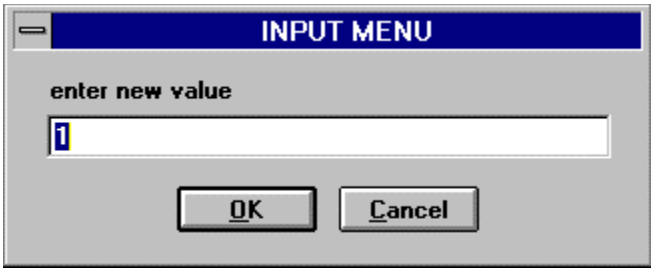


Figure 4

inputfocus — *Array Variable with Current Focus*

Syntax: x = **inputfocus**

Description: Sets the defined variable equal to the variable whose window currently has focus.

See Also: M_inputfocus

int — *Integer part*

Syntax: **int**(a) or a.**int**

Description: Computes the integer part for each element in the input array, 'a'.

int2str — *Convert an Integer to a String*

Syntax: **int2str**(a) or **int2str**(a,$format)

Description: Converts the input real scalar to an integer number and then to a string representation. The user can control the format by providing a controlling string, i.e. $format, which follows the standard C language approach.

Example:

```
x = 4.32
int2str(x)          // conversion to integer string representation

x = 10
int2str(x, "%x")    // conversion to hexadecimal string representation
```

int_tabulated_vec Computes integrals of tabular data (Newton-Cotes)

Syntax: **i = int_tabulated_vec(x, y)**

Description: Computes the integral value of the input functions, given as a sets of tabular data.

The function works on a row basis: each row of the input arguments is treated as a tabulated function, where xi, i = 1..n are the sampling points and yi = f(xi) are the corresponding function values at those points.

The input x vectors must be in ascending order and cannot contain duplicates values, i.e.: x1 < x2 < … xn

If any of the input row values is a NaN, then a NaN value is returned as the integral value for that row.

Implementation: Each input tabulated function is interpolated using cubic splines, then the integral is computed over the closed [x1..xn] interval using the 5 points Newton-Cotes formula.

Example:

```
x = sortr( 30*randu( 13, 42 ) )
y = 3*randu( 13, 42 ) + sin(x)
iv = int_tabulated_vec( x, y )

/* iv is a column vector containing the integral values of the input
functions */
```

int_tabulated_sums Computes integrals of tabular data (Trapezoids rule)

Syntax: **i = int_tabulated_sums(x, y)**

Description: Computes the integral value of the input functions, given as a sets of tabular data.

The function works on a row basis: each row of the input arguments is treated as a tabulated function, where xi, i = 1..n are the sampling points and yi = f(xi) are the corresponding function values at those points.

The input x vectors must be in ascending order and cannot contain duplicates values, i.e.: x1 < x2 < … xn

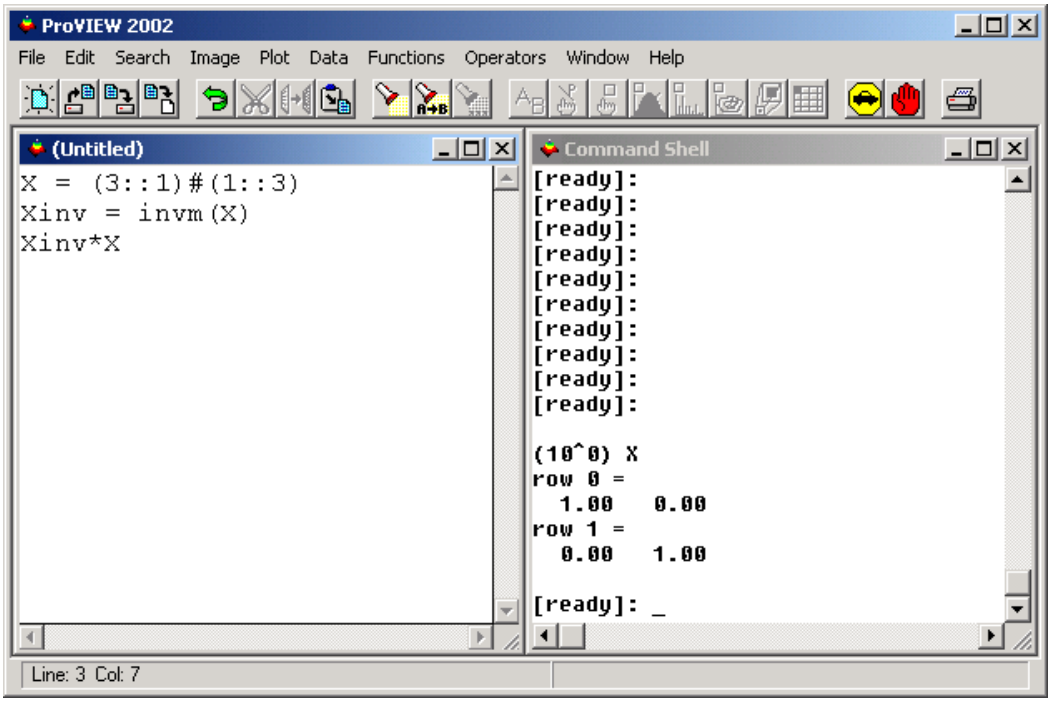
If any of the input row values is a NaN, then a NaN value is returned as the integral value for that row.

Implementation: Each input tabulated function is integrated using the Trapezoids rule (simply summing the areas of the trapezoids).

invm *Inverse of an Array*

Syntax: **invm**(a)

Description: Computes the inverse of matrix "a", so that "a" multiplyed by its inverse equals the identity matrix.



itoa *Integer to Ascii (same as int2str)*

Syntax: **itoa(**x**)**

Description: Converts the integer ‘x’ to a string. See ‘int2str’.

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---

ladd — *Local add operator*

Syntax: **ladd**(a, b **)**

Description: This command performs the operation of *a* + *b* and assigns the result directly to *a*. The input parameter *a* is thus modified after the call to this command. MSHELL will take care of doing internal checking for not corrupting shared arrays.

---

ladd2groi — *local add of constant to selected pixels*

Syntax: **ladd2groi(**X,groi,V**)**

Description: Increments every pixel in X(groi) by scalar (or row vector) 'V'. **This function permanently modifies the content of X**, The following MSHELL instruction make use of this function with internal checking for not corrupting shared arrays.

a(groi)++

a+=b

a(groi)+=b

Hence try to use the above as opposed to directly using ladd2groi.

Example: The following illustrates the operation.

```
x                   = (0,10,1)
x2                  = x^2
groi                = rindex(x,5,8)
b                   = -x(groi)^2

print "x ="::float2str(x,"%7.0f")::"\n"

a1                  =   x
a1                  +=  x2
print "a1="::float2str(a1,"%7.0f")::"\n"
a2                  =   x
a2(groi)+=          1
print "a2="::float2str(a2,"%7.0f")::"\n"
a3                  =   x2
a3(groi)+=          b
print "a3="::float2str(a3,"%7.0f")::"\n"
a4                  = x2
a4(groi)+=          -x(groi)^2
print "a4="::float2str(a4,"%7.0f")::"\n"
```

The above code generates the following output:

x = 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

a1= 0, 2, 6, 12, 20, 30, 42, 56, 72, 90, 110

a2= 0, 1, 2, 3, 4, 6, 7, 8, 9, 9, 10

a3= 0, 1, 4, 9, 16, -600, -1260, -2352, -4032, 81, 100

a4= 0, 1, 4, 9, 16, 0, 0, 0, 0, 81, 100

leclipto Lower or Equal Clip to

Syntax: **leclipto**(a,tval,newval)

Description: Set all the values in the input array, ‘a’, that are less than or equal to a selected threshold value, ‘tval’, to a new desired value, ‘newval’.

Example: The following illustrates the operation.

```
[ready]: a = randu(1,7)
[ready]: a
row 0 =
  0.43   0.43   0.57   0.09   0.78   0.56   0.74
[ready]: leclipto(a,.50,1)
row 0 =
  1.00   1.00   0.57   1.00   0.78   0.56   0.74
```

leindex *Lower or Equal Index*

Syntax: **leindex**(a,b)

Description: Similar to **eqindex** , but returns an index to all elements in 'a' lower than or equal to 'b'.

Example: Using the array 'a', previously defined in **leclipto**,

```
[ready]: a = randu(1,7)
[ready]: leindex(a,.5)
row 0 =
  0.00  -0.00i   1.00  -0.00i   3.00  -0.00i
```

legpoly *Associated Legendre Polynomials*

Syntax: **legpoly** (n, m, x)

Description: Computes the canonical solutions $P_{n,m}(x)$ of the general Legendre equation:

$$(1-x^2)\,y'' - 2xy' + \left(n[n+1] - \frac{m^2}{1-x^2}\right) y = 0$$

where *n* and *m* are referred as the degree and order of the associated Legendre polynomial respectively. The Legendre equation has nonzero solutions (called "associated Legendre polynomials") that are non-singular on x = [-1, 1] only if n and m are integers with $0 \le m \le n$.

legpolyn *Fully Normalized Associated Legendre Polynomials*

Syntax: **legpolyn** (n, m, x)

Description: Computes the fully normalized associated Legendre polynomials. It can be computed from the conventional associated Legendre polynomials $P_{n,m}(x)$ by:

$$\bar{P}_{n,m}(x) = \sqrt{k(2n+1)\frac{(n-m)!}{(n+m)!}}\,P_{n,m}(x)$$

linterp Linear Interpolation

Syntax: **linterp**(f,x)

Description: Linearly interpolates between data points located on a one dimensional grid. The function argument, 'f', is a 1-dimensional row vector with an assumed interpixel distance of 1 along the axis, i.e. the element values of 'f' can be considered the ordinate values for some function over a set of increasing (or decreasing) abscissa values. The argument 'x' is a real 1-Dimensional row vector containing values of the abscissa for which ordinate values are to be linearly interpolated. For every point that extrapolation is attempted the result is set to zero.

Example: The following two examples illustrate the function.

```
[ready]: f = hammiw(1,4)
[ready]: f
(10^0) X
row 0 =
  0.01   0.04   0.08   0.04     // assumed abscissa values of: 0, 1, 2,
3
[ready]: x = (-1,7,1) * 0.5
[ready]:  x
 -0.50   0.00   0.50   1.00   1.50   2.00   2.50   3.00   3.50
[ready]: linterp(f,x)
  0.00   0.01   0.02   0.04   0.06   0.08   0.06   0.04   0.00
[ready]: y = 0.2
[ready]: linterp(f,y)
  0.01376
```

lmulte Local element-wise multiplication operator

Syntax: **lmulte**(a, b **)**

Description: This command performs the operation of *a *. b* and assigns the result directly to *a*. The input parameter *a* is thus modified after the call to this command. MSHELL will take care of doing internal checking for not corrupting shared arrays.

lmulte_cols Local element-wise column multiplication operator

Syntax: **lmulte_cols**(a, b **)**

Description: This command multiplies each column of *a* with the column vector *b* element by element and assigns the result directly to *a*. The input parameter *a* is thus modified after the call to this command. MSHELL will take care of doing internal checking for not corrupting shared arrays.

load *Loads saved arrays or strings from a file*

Syntax: **load** $savefile

Description: Loads arrays or strings from the $savefile.

See Also: **save**

LOCAL *Declare a locally scoped variable*

Syntax: **LOCAL** my_array

Description: Declares a variable local to the MSF function. Only necessary when in the **LOCALOFF** mode.

LOCALON *Turn on locally scoped variables*

Syntax: **LOCALON**

Description: Used in an MSF function. Variables referenced after this command will **NOT** affect top level variables, but will reference local function variables. By default MSF functions are in the LOCALON state.

LOCALOFF *Turn off locally scoped variables*

Syntax: **LOCALOFF**

Description: Used in an MSF function. Variables referenced after this command will affect variables defined outside of the local function, instead of referencing local function variables. Use with caution!! By default MSF functions are in the LOCALON state.

localtimenow *Local Time Now*

Syntax: **localtimenow()**

Description: Returns the current system time as a column vector. Columns 0-5 correspond to year,month,day,hour,minute,second. Column 6 is the day of the week (Sunday=0). Column 7 is the Julian day. If x=localtimenow(), then x.text will have a nicely formatted time string.

Example:

```
ready: t = localtimenow()
ready: t

(10^0) X
row 0 =
  2004.00      7.00      8.00     10.00     43.00     59.58      4.00
   190.00      1.00

ready: t.text
2004-07-08T10:43:59.578
```

see also: gmtimenow()

---

log *Natural Logarithm*

Syntax: **log**(a) or a.**log**

Description: Computes the natural logarithm of each array element. The actual mathematical expression computed is given by,

$$c_{j,i} = \log(a_{j,i}) \quad \text{for all j, i;}$$

where j and i are row and column indices respectively.

The **Log** of zero is not defined and will generate an error, where as the **Log** of a negative number will generate a complex number.

Example: The following MSHELL statement will compute the natural logarithm of 'a' and store the result in 'c',

```
[ready]: c = log(a)
```

---

log10 *Base 10 Logarithm*

Syntax: **log10**(a) or a.**log10**

Description: Compute the base 10 logarithm of each array element. The **Log10** of zero is not defined and will generate an error, whereas the **Log10** of a negative number will generate a complex number. The actual mathematical expression computed is given by,

$$c_{j,i} = \log_{10}(a_{j,i}) \quad \text{for all j, i;}$$

where j and i are row and column indices respectively.

Example: The following MSHELL statement will compute the base 10 logarithm of ‘a’ and store the result in ‘c’,

```
[ready]: c = log10(a)
```

ltclipto Lower than Clip to

Syntax: **ltclipto**(a,tval,newval)

Description: Set all the values in the input array, ‘a’, below a selected threshold value, ‘tval’, to a new desired value, ‘newval’.

Example: Using the array ‘a’, previously defined in **leclipto**,

```
 [ready]: ltclipto(a,0.5,.0.2)
row 0 =
  0.20   0.20   0.57   0.20   0.78   0.56   0.74
```

lthresh Less than Threshold

Syntax: **lthresh**(a,b)

Description: This sets all values within "a" which are less than the treshold "b" equal to the threshold.

ltindex Lower Index

Syntax: **ltindex**(a,b)

Description: Similar to **eqindex** , but it returns an index to all elements in ‘a’ lower than ‘b’.

Example: Using the array ‘a’, previously defined in **leclipto**,

```
[ready]: ltindex(a,.5)
row 0 =
  0.00-  0.00i   1.00-  0.00i   3.00-  0.00i
```

Look-up-Table LUT associated to image

Syntax: **x.LUT** and **x.LUTdef**

Description: *Note: This capability was incorporated in MSHELL version 3.* Given an image 'x', you can set or read an associated look-up-table to this variable using the 'x.LUT'. Once assigned, if the user sents the image for display (using view or view255) the view command will make use of the assigned LUT.

'x.LUTdef' is used to save a copy of the default palette that gets loaded when the image is read from disk. If the user modifies 'x.LUT' the original state can be restored with 'x.LUT = x.LUTdef'

Example:

```
x = reada("eqohare.chr","char");    // open and image
view x;                                     // gray scale palette
y = x;                                      // assign x to y
y.LUT = (255,0,1,3)             // assign an inverse palette to y
view y;                                     // inverted palette
z = x;
z.LUT  = reada(M_proviewdir::"/palettes/apl_wind.asc","ascii"); //
color palette
view z;                                     // color palette
```

All the palettes available are located in the 'palettes' directory.

M_ System Variables

Description: System variables are used to control different functions within the MSHELL environment. Some of the MSHELL system variables are strings while others are numbers. All system variables are prefixed by '**M_**'. For example, to initialize the x-axis label to the string "Time" use, **M_xlabel** = "Time". If you create your own M_ variable, e.g. M_mine=3, it will behave as system variable, i.e. it will be accessible from inside any script of function.

Note that system string variables do not required the '$' symbol normally associated with user defined string variables. System variables can be read into other user defined variables, e.g. $message = **M_xlabel**, is a legal construction.

Approximately three quarters of the system variables are used in controlling the **plot** and **plot3d** function output.

The following list categorize and describes the various system variables.

See **include system files** in this section for **sysedit.msh** which allows the user to change all system variables at one time from a table. Also, under the Edit menu one can find the Edit System Variables item which calls sysedit.msh.

Plot Related Variables

M_axis When using **plot3d** you can control if a numeric axis is drawn or not using the **M_axis** string; (string variable). If **M_axis** is set to "xyz" all the axis will be drawn. If x,y, or z is omitted from the string the corresponding axis is also omitted.

M_blabel Bottom label used in plots; (string variable).

M_device Output plot device, values: 0 = DT2861/AL860HRG, 1 = plot file format, 2 = Windows Screen (default)

M_fxaxis Used to control the number of digits used in the x-axis, see **M_format** for more information.

M_fyaxis Similar to **M_fxaxis** but for the y-axis.

M_fzaxis Similar to **M_fxaxis** but for the z-axis.

M_hidden If set to 0 hidden line removal will not be used in **plot3d**; default value is 1 (use hidden line removal).

M_holdx Sets axis display: if 0 display is the extent of the data, if 1 display is limited by **M_xmin** and **M_xmax**

M_holdy Similar to **M_holdx** but for y.

M_holdz Similar to **M_holdx** but for z.

M_linetype Sets plot line type style. Valid line styles are: 0, for symbol; 1, for solid line; and 2, for spikes.

M_panel If set to 1 a side panel will be used in the **plot3d**; default value is 0.

M_phi1 Select rotation around z axis in **3dplot**: values range between -**90** and **90** (degrees).

M_phi2 Select out of plane angle in **3dplot**: values range between **-90** and **90** (degrees).

M_tlabel Title label; (string variable).

M_xdir If set to 0 only the lines of constant x values will appear in a **plot3d**; default value is 1.

M_xlabel X axis label; (string variable).

M_xlog Log scale of x-axis, valid values are 0, 1, 2, or 3. If set to: 0 the option is disabled; 1, 2, or 3 yield logarithmic scaling with increasing resolution; applicable to **plot** only.

M_xmax Set maximum x-axis value, use **M_holdx** = 0 to cancel, **M_holdx** = 1 to restore.

M_xmin Set minimum x-axis value, use **M_holdx** = 0 to cancel, **M_holdx** = 1 to restore.

M_xnice If set to 1 the max. and min. for the x-axis are computedsuch that a nice set of numbers is selected.

M_xtic Used to control the spacing of tic marks along the x-axis; default value is 1. Only applies if **M_xnice** is set to zero.

M_ydir Similar to **M_xdir** but for y.

M_ylabel Similar to **M_xlabel** but for y.

M_ylog Similar to **M_xlog** but for y-axis.

M_ymax Set maximum y axis value, use **M_holdy** = 0 to cancel, **M_holdy** = 1 to restore.

M_ymin Set minimum y axis value, use **M_holdy** = 0 to cancel, **M_holdy** = 1 to restore.

M_ynice Similar to **M_xnice** but for y-axis.

M_ytic Similar to **M_xtic** but for y-axis.

M_zlabel Similar to **M_xlable** but for z.

M_zmax Maximum z axis value.

M_zmin Minimum z axis value.

M_ztic Similar to **M_xtic** but for z-axis.

M_xorigin x offset for the left of the plot output

M_yorigin y offset for the top of the plot output

M_xlen length of x-axis (?? units)

M_ylen length of y-axis (?? units)

M_zlen length of z-axis (?? units)

M_sym point symbols used when M_linetype is zero.

1 = squares with a top center tickmark
2 = circles with a a top center tickmark
3 = triangles with a top center tickmark
4 = Y shaped marks
5 = X shaped marks
6 = diamonds with a top center tickmark
7 = little umbrella looking symbols
8 = little hourglass looking symbols
9 = Z shaped marks
10 = squares, corner ticks and upper right to center tick
11 = asterisks
12 = plus symbols
13 = diamonds

M_height Font height of plot axis annotations

M_panel For plot3d, draw vertical lines on the front panels

M_plotcolor graylevel (0-255) of plotting output

M_ndigits **reserved**

M_xdigits **reserved**

M_ydigits **reserved**

M_zdigits **reserved**

M_scalef	**reserved**
M_deltac	**reserved**
M_deltar	**reserved**
M_digits	**reserved**
M_contour_view	**reserved**
M_edit	**reserved**

Text Output

M_format Controls the number of digits used when printing values to the Command Line Window screen. For example, **M_format** = "00.000" specifies that the largest value that can be represented, excluding the exponent, is 99.999. Anything larger than this is printed as ##.###.

M_ifont used to specify image font type (text2image)Currently 'times' is the only option

M_ptsize Controls the font size to be used when overlaying text to images using the text2image commands; the available point sizes are: 9, 10, 12, 14, 18, and 24.

Time Related Variables

M_time Returns the system time; this variable is read only, no value is needed or assigned.

System Related Variables

M_cwd Sets the current working directory. For example, to set 'c:/mydir' as the current working directory type: **M_cwd** = "c:/mydir"

M_path The path string assigned to this variable will be searched when trying to open an input file. For example, to set **M_path** to the directorys 'c:/mshell/bin' & 'c:/mshell/msf' type: **M_path** = "c:/mshell/bin; c:/mshell/msf".

M_wdb Contains word-data-base file to use when drawing coast-lines using the dworld() function.

M_windir This is the windows root directory.

M_echo This toggles the display of executed commands within a script file.
M_echo=10 causes all commands to be displayed as they are performed.
M_echo=5 is nominal output.
M_echo=0 will prohibit all printing, including explicit print statements.

M_prompt Sets the command prompt text (MSHELL console mode only)

M_windir Shows the WINDOWS Root directory (WIN32 Only)

M_proviewdir Shows the PROVIEW root directory

M_errorscript contains name of error script to execute in the event of an error. If empty, no error script is executed. By default, MSHELL starts 'M_errorscript' empty.

M_errorstring String output of last error encountered

M_temp_unpid Temporary directory, unique for the current session

M_appname Name of the upper-level application (i.e ACT-REACT)

M_cmd_source Name of the command source being executing (e.g. scripts name)

M_cmd_line Current line number of execution

M_version The ProVIEW/MSHELL version number.
Note: After version 3, significant changes in the handling of the color palette where introduced via the 'x.LUT' image attribute.

M_versionstring The ACT-MSHELL build number together with the Copyright string.

M_nprint Entering this alone will send a screenshot to the current default printer (GUI only)

M_inputfocus provides name of image that has the present or last input focus of the GUI

M_xpix Obsolete, see array window operators m_viewx0 and m_viewy0.

M_ypix Obsolete, see array window operators m_viewx0 and m_viewy0.

M_logmode 0=send output to STDOUT only (default)
1=send output to M_logfile
2=send output to STDOUT and M_logfile

M_logfile used as the output file (including path)

M_OS provides the operating system under which the interpreter is running (UNIX or Windows_NT)
Note: this system variable is obsolete and it is provdided to keep old scripts working. We strongly advise against using it in new code (use M_OS_type, instead).

M_OS_type string variable that provides the platform name under which the interpreter is running ("WINDOWS", "LINUX" or "MACOSX").

M_processid provides process id on current session

M_execution_mode
provides execution mode for the version of the executable that is using MSHELL, e.g.
GUI, or CGI, or CONSOLE.

M_use_scripts_indexing
0 = scripts indexing is disabled (default on CGI)
1 = scripts indexing is enabled (default on GUI or CONSOLE)
Scripts indexing is a mechanism that speeds up the time to look for a script file on the file system during an "include" call or a function script

call. On the other side, there is an initial overhead due to the time to create the lookup table of the indexed scripts.

M_use_scripts_caching

0 = scripts caching is disabled
1 = scripts caching is enabled (default)
Scripts caching is a mechanism that speeds up the time to load a script file during an "include" call or a function script call.

M_tprofile_enabled

0 = disable time profiling
1 = enable time profiling
Time profiling is a set of commands that can be used to measure the execution time of blocks of code and to manage the resulting profiling data (i.e. print a report).

M_mprofile_enabled

0 = disable MSHELL profiling
1 = enable MSHELL profiling
When enabled, MSHELL automatically measures many internal profiling statistics, such as the average scripts call time, number of variable lookups, etc. and gives the ability to access the resulting profiling data (i.e. print a report).

Network related

M_min_xfer_rate

can be set to specify the minimum allowed transfer rate (in Bytes per Second); if the transfer goes below this threshold for more than 10 seconds the transfer is aborted. This behavior can be disabled by setting the value to -1.

CGI mode

M_cgi 1 means running in cgi model, 0 otherwise.

M_ipaddr Only in web-based mode, show the IP addr of the client

M_wwwroot This is the root www directory, which is used when in cgi mode.

M_xtype Contains the requested output document type HTTP header (Content-type). This must be set when provweb.exe is called (i.e. http://server.com/cgi-bin/provweb.exe?_xtype=text/html ...) Note the variable name there is _xtype. The output behaviour is as follows:

Blank – ProVIEW-Web begins a "text/html" document, with fixed font formatting (<HTML><PRE>…) If you don't want the fixed font (<PRE> mode), you must specify the output document type, such as text/html explicitly. This simple default behaviour is called ProVIEW-Web Calculator mode.

"dynamic" – ProVIEW web sends **NO** "Content-type" header. It is up to the script being executed to output this string. It must be of the format: "**Content-type: type/sub-type\n\n"** (i.e. **print "Content-type: text/html\n\n"**). The blank line is essential for separating the header from the document data.

type/sub-type – ProVIEW-Web will send the Content-type header using the specified type/sub-type. (i.e. text/plain, or image/jpeg)

M_cgiview Image file output format when using **view** command in ProVIEW-Web

M_olutn Holds the index of the current look-up-table used for displaying an image.

Math Related

M_matherrflag Selects the manner in which math errors or exceptions are reported and handled. If **M_matherrflag** = 0, no errors are reported. If **M_matherrflag** = 1, mathematical exceptions are reported and script file execution halted until you acknowledge by clicking in a popup window. If **M_matherrflag** is set equal to 2, mathematical exceptions are reported and script file execution is halted.

M_NaN holds the representation of an IEEE NaN.

Interpolation Related

M_interp Indicates which interpolation method is preferred: zero-order nterpolation (**M_interp** = 0), or linear/bilinear interpolation (**M_interp** = 1).

M_no_data Blinterp will not interpolate if an intensity value in an image is set to M_no_data.

Data Loading Related

M_maxdim This variable is used by the reada($fname,"all") call. In particular when loading raster data using the 'all' mode, it determines the maximum dimension of the array that the input image is loaded into. This is particularly usefull when loading large raster images, e.g. 10,000 x 5,000 pixels.

M_no_data Blinterp will not interpolate if an intensity value in an image is set to M_no_data.

m_ Array Window Operators

Syntax: **m_xxxx**(a)

Say 'x' is an image, then image.m_x0 is an image attribute.

A detail list of all the static attributes can be found in the section: Intrinsic Attributes Associated with Array Variables, see page 24.

See **include imgedit.msh** which allows the user to change all image attributes at one time from a table. Also, under the Image menu one can find the Edit Image Attributes item which calls imgedit.msh.

makecmplx converts a real array to complex

Syntax: **makecmplx(**x**)**

Description: converts real array to complex form

Example: The following demonstrates the operation.

```
[ready]: y = makecmplx(5)
[ready]: y
row 0 =
  5 + 0i
```

makegrid Create a grid

Syntax: **makegrid(from_x, to_x, from_y, to_y, dx, dy)**

Description: This function returns a complex output image with real values bounded between [from_x,to_x] at a pace of dx and imaginary values bounded between [from_y,to_y] at a pace of dy.

makegridN Create a NxM grid

Syntax: **makegridN(from_x, to_x, from_y, to_y, N, M)**

Description: This function returns a complex output image with real values bounded between [from_x,to_x] and imaginary values bounded between [from_y,to_y]. The *X* range is divided into *N* intervals and the *Y* range is divided into *M* intervals so the output array has a dimenion of (N+1)x(M+1).

maskofBitPlane *mask of bit plane n*

Syntax: **maskofBitPlane(a,N,n)**

Description: return image mask with value of 0 or 1. The values will hold the bit plane 'n'. It is assumed that the input array 'a' is holding unsiged integer values coming from an integer with Nth bits. Say N = 2, then value highest value representable is 3, and bit plane n=0 corresponds to the least significant.

This function is usefull to extract encoded mask planes into integer arrays. For example one bit plane could be storing a land mask, and another cloud masks.

maskofEQ *mask of elemens where a==b*

Syntax: **maskofEQ(a,b)**

Description: return image mask with a value of one for all the pixels where a(j,i)==b(j,i). All of the maskofXX functions, e..g maskofGE(), maskofLE(), …, only accept real input arrays.

maskofGE *mask of elemens where a>=b*

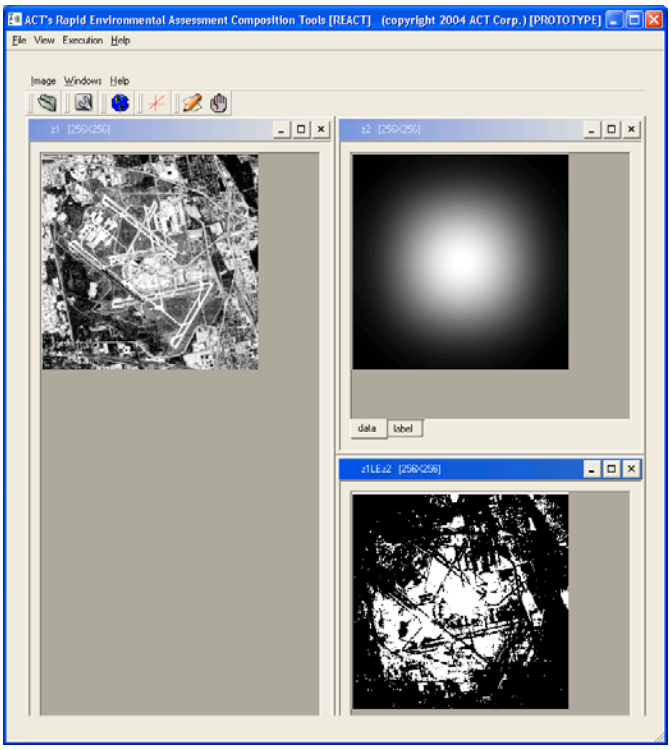
Syntax: **maskofGE(a,b)**

Description: return image mask with a value of one for all the pixels where a(j,i)>=b(j,i). All of the maskofXX functions, e..g maskofGE(), maskofLE(), …, only accept real input arrays.

Example: The following code demonstrates maskofGE(), maskofGT(), maskofLT(), and maskofLE().

```
free all
y = hammiw(256,256)        // test pattern image
view255 y;
show y

// tests array against a constast
le=maskofLE(y,0.5)
view255 le

lt = maskofLT(y,0.5)
```

```
view255 lt

gt=maskofGT(y,0.9);
view255 gt
ge=maskofGE(y,0.9);
view255 ge

wtile

pause(-1);
free all
// test and array against another array
z1 = reada(M_proviewdir::"/images/eqohare.chr","char");
z2 = hammiw(z1.nrows,z1.ncols)*255
view255 z1
view255 z2
z1LEz2 = maskofLE(z1,z2)
view255 z1LEz2
```


ACT's Rapid Environmental Assessment Composition Tools [REACT] (copyright 2004 ACT Corp.) [PROTOTYPE]
File View Execution Help
Image Windows Help
data
label

---

maskofGT — *mask of elemens where a>b*

Syntax: **maskofGT(a,b)**

Description: return image mask with a value of one for all the pixels where a(j,i)> b(j,i)

maskofLE — *mask of elemens where a<=b*

Syntax: **maskofLE(a,b)**

Description: return image mask with a value of one for all the pixels where a(j,i)<=b(j,i)

maskofLT — *mask of elemens where a<b*

Syntax: **maskofLT(a,b)**

Description: return image mask with a value of one for all the pixels where a(j,i)<b(j,i)

max — *Maximum in Array*

Syntax: **max**(a) or a.**max**

Description: Find the maximum value of all the elements in the input array. Note that this function is only valid for real input arrays.

Example: The following demonstrates the operation.

```
[ready]: a = randu(1,8)
[ready]: a
row 0 =
  0.02   0.46   0.64   0.96   0.34   0.57   0.08   0.60
[ready]: max(a)
    0.95636
```

maxmin — *Max and Min values in Array*

Syntax: **maxmin**(a) or a.**maxmin**

Description: Find the maximum and minimum values of all the elements in the input array. Note that this function is only valid for real input arrays.

Example: The following demonstrates the process.

```
[ready]: a = randu(1,100) //create a vector of random numbers
[ready]: maxmin(a)
row 0 =
  1.00   0.01
```

maxminr Max&Min values in Array with range constraint

Syntax: **maxminr**(a, lower_bound, upper_bound)

Description: Find the maximum and minimum values of all the elements in the input array, excluding all values that do not fall within the range lower_bound-upper_bound. Note that this function is only valid for real input arrays.

Example: The following demonstrates the process.

```
[ready]: a = int( 100*randu(5,5) )
[ready]: maxmin( a )
row 0 =
  96.00   8.00
[ready]: maxminr( a, 20, 50 )
row 0 =
  40.00   25.00
```

maxminx Max and Min values in Array with exclusion

Syntax: **maxminx**(a,exclude)

Description: Find the maximum and minimum values of all the elements in the input array, after excluding all the values in array 'exclude'. Note that this function is only valid for real input arrays.

Example: The following demonstrates the process.

```
[ready]: a = randu(100,100)
[ready]: a(0,0)= 200
[ready]: maxminx(a,200)
row 0 =
  1.00   0.01
```

maxof *Element by Element Maximum*

Syntax: **maxof**(a,b)

Description: Computes the maximum on an element by element basis. In general, the two input arrays must have the same dimensions. The only exception to this is when one of the input arrays is a scalar. Note that this function is only valid for real input arrays.

Example: The following demonstrates the process.

```
[ready]: x = randu(2,2)
[ready]: x
row 0 =
  0.01   0.22
row 1 =
  0.12   0.38
[ready]: y = randu(2,2)
[ready]: y
row 0 =
  0.48   0.02
row 1 =
  0.56   0.73
[ready]: maxof(x,y)
row 0 =
  0.48   0.22
row 1 =
  0.56   0.73
```

maxr *Row Maximum*

Syntax: **maxr**(a)

Description: Computes the maximum for each row of array "a" and strores these values as a column vector.

mbox *Text Box*

Syntax: **mbox(**$string**)**

Description: Prints to string to a dialog box on the screen.

mean *Mean of Array Elements*

Syntax: **mean**(a) or a.**mean**

Description: This module computes the mean of all the elements in the input array. The formula used to compute the mean is

$$c_{0,0} = \frac{1}{I \cdot J} \sum_{i=0}^{I-1} \sum_{j=0}^{J-1} a_{j,i} \quad \text{for all j, i}$$

where j and i are row and column indices respectively.

Example: The following demonstrates the application.

```
[ready]: a = randu(2,100)   //create a matrix of ran. num.
[ready]: mean(a)
    0.503304
```

median *Compute Median Value*

Syntax: **median**(a)

Description: Compute the median value of all the elements in the input array. The output is a scalar, i.e., a 1x1 array.

Example: The following demonstrates the process.

```
[ready]: a = randu(2,100)
[ready]: median(a)
    0.502454
```

medianc *Column Wise Median*

Syntax: **medianc(**a) or a.**medianc**

Description: Compute the median value along each column of the input array. The output is a row vector with the number of elements equal to the number of columns in the input array ‘a’.

Example: The following demonstrates the process.

```
[ready]: a = randu(100,7)
[ready]: medianc(a)'
  0.56   0.51   0.57   0.48   0.59   0.40   0.43
```

medianr *Row Wise Median*

Syntax: **medianr(**a) or a.**medianr**

Description: Compute the median value along each row of the input array. The output is a column vector with the number of elements equal to the number of rows in the input array 'a'.

Example: The following demonstrates the process.

```
[ready]: a = randu(7,100)
[ready]: medianr(a)'
    0.46
    0.53
    0.47
    0.48
    0.47
    0.53
    0.48
```

memory_map *Print information on variables in memory*

Syntax: **memory_map**

Description: Print system information on variables in memory (name, type, dimension, memory address). It also prints the amount of allocated memory for variables.

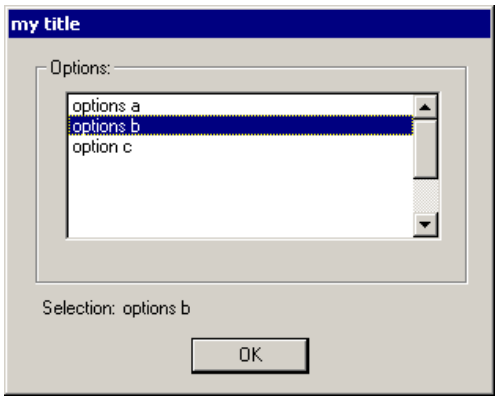
menusel *creates a Menu List Box*

Syntax: **menusel(**$title, $options**)**

Description: creates a menu list box, using the $title and $options provided to the function. Every row in $options is treated as a different option. Execution is stopped until the user selects an option and hits OK. The function returns a string with the option selected.

Example:

```
$item = menusel("my title","options a\noptions b\noption c")
```



meter *Displays a Metering Toolbar*

Syntax: **meter**($string, value)

Description: Draws a meter toolbar on the lower right hand corner of the screen. The first argument, '$string' is a text string used for description purposes. The second argumet, 'value', is a scaler whose value controls the behavior of the meter toolbar. If 'value' < 0 the meter toolbar is erased, if 0 <= 'value' <= 100 the meter toolbar is drawn with 'value' as a percent. If 'value' > 100 an error occurs.

Example: The following script file draws a meter toolbar.

```
i=0
while(i<100){
    i = i+1
    meter("hello",i);
}
meter("hello",-1)
```

min *Minimum in Array*

Syntax: **min**(a) or a.**min**

Description: Find the minimum value of all the elements in the input array. Note that this function is only valid for real input arrays.

Example: The following demonstrates the process.

```
[ready]: a = (-2,2,1,2)
row 0 =
 -2.00  -1.00   0.00   1.00   2.00
row 1 =
 -2.00  -1.00   0.00   1.00   2.00
[ready]: min(a)
    -2
```

minof *Element by Element Minimum*

Syntax: **minof**(a,b)

Description: Compute the minimum on an element by element basis. In general, the two input arrays must have the same dimensions. The only exception to this is when one of the input arrays is a scalar. Note that this function is only valid for real input arrays.

Example: The following demonstrates the process.

```
[ready]: b = (-4,4,2,2)
[ready]: b
row 0 =
 -4.00  -2.00   0.00   2.00   4.00
row 1 =
 -4.00  -2.00   0.00   2.00   4.00
[ready]: a = (0,4,1,2)
[ready]: a
row 0 =
  0.00   1.00   2.00   3.00   4.00
row 1 =
  0.00   1.00   2.00   3.00   4.00
[ready]: minof(a,b)
row 0 =
 -4.00  -2.00   0.00   2.00   4.00
row 1 =
 -4.00  -2.00   0.00   2.00   4.00
```

minr *Row Minimum*

Syntax: **minr**(a)

Description: Computes the minimum for each row of array "a" and strores these values as a column vector.

mjd2dt Convert Modified Julian Date

Syntax: **mjd2dt(**mjd_value)

Description: Converts a **Modified Julian Date** to a vector giving year,month,day, hour, minute, second.

Example: The following MSHELL statement will find the date vector given a julian day number (of a given year)

```
[ready]: jdoy = 10   // find date for the 10th day of 2002
[ready]: jy = dt2mjd(2002::1::1::0::0::0)
[ready]: dt = mjd2dt(jy+ jdoy -1)
[ready]: dt
(10^0) X
row 0 =
  2002.0000      1.0000     10.0000      0.0000      0.0000      0.0000
```

momentr Row Wise Moment

Syntax: **momentr**(a,x)

Description: Compute the x^{th} moment along each row of the input array, where 'x' can be real or complex. The moment of the j^{th} row is defined as:

$$\sum_{i=0}^{a.ncols-1} a_{j,i}^{x}$$

Example: **T**he MSHELL statements on the following page will compute the second moment of each row of the array 'a' and assign the values to 'b'.

```
[ready]: a = randu(100,5)
[ready]: b = momentr(a,2)
[ready]: show a
       --- a ---
data type is      : real
number of rows    = 100
number of columns = 5
maximum value     = 0.995382
minimum value     = 0.00161857
[ready]: show b
       --- b ---
data type is      : real
number of rows    = 1
number of columns = 5
maximum value     = 7.25416
minimum value     = 5.92651
[ready]: b
  6.48   7.25   7.18   6.13   5.93
```

mpath_add — *Add a new path to M_path*

Syntax: **mpath_add**($path)

Description: This command adds a new path to M_path. It scans the specified path looking for MSHELL scripts (.msh) and MSHELL Function scripts (.msf) and indexes all found scripts. Returns zero upon successful (path exists and is readable), not zero upon failure (.text attribute has a brief description of the error).

mpath_addr — *Add a paths tree to M_path*

Syntax: **mpath_addr**($path)

Description: This command adds recursively the entire paths tree starting at path $path to M_path. This function attempts to add as many paths as it can stopping at the first unexisting/unreadable path. For every added path, it scans the current directory looking for MSHELL scripts (.msh) and MSHELL Function scripts (.msf) and indexes all found scripts. Returns zero upon successful (all paths exist and are readable), not zero upon failure (.text attribute has a brief description of the error).

mpath_remove — *Remove a path from M_path*

Syntax: **mpath_remove**($path)

Description: This command attempts to remove the specified path from M_path (if present). It also removes all previously indexed scripts that were located in the specified path.

mpath_remover — *Remove a paths tree from M_path*

Syntax: **mpath_remover**($path)

Description: This command removes the entire paths tree starting at path $path from M_path. This function attempts to remove as many paths as it can, ignoring paths that are not present in M_path. For every removed path, it also removes all previously indexed scripts.

mpath_haspath — *Test whether a path is in M_path*

Syntax: **mpath_haspath**($path)

Description: If M_path contains $path it returns a non-zero value, otherwise it returns 0.

mpath_subpaths — *Return M_path sub-paths entries*

Syntax: **mpath_subpaths**($path)

Description: This command returns all M_path entries that are sub-paths of the specified $path.

mpath_clear — *Clear M_path*

Syntax: **mpath_clear**()

Description: This command clears M_path system variable.

mprofile_reset — *Reset MSHELL Profiling data*

Syntax: **mprofile_reset**()

Description: This command resets MSHELL profiling data. This is useful to start a new MSHELL performance mensuration session.

mprofile_stats — *MSHELL Profiling statistics*

Syntax: **mprofile_stats**()

Description: This command can be used to print the current MSHELL Profiling statistics.

mscripts_mshlist *Return the list of indexed MSHELL scripts*

Syntax: **mpath_clear**()

Description: This command returns the complete list of indexed MSHELL Scripts (.msh only).

mscripts_msflist *Return the list of indexed MSHELL function scripts*

Syntax: **mpath_clear**()

Description: This command returns the complete list of indexed MSHELL Function Scripts (.msf only).

mscripts_list *Return the entire list of indexed MSHELL scripts*

Syntax: **mpath_clear**()

Description: This command returns the entire list of indexed MSHELL Scripts and MSHELL Function Scripts (.msh and .msf).

mscripts_refresh *Refresh the list of indexed MSHELL scripts*

Syntax: **mpath_refresh**()

Description: This command refresh the entire list of indexed MSHELL Scripts and MSHELL Function Scripts (.msh and .msf) by scanning all *M_path* paths.

mshift_u16 *Bitwise shifting (16-bits unsigned integer)*

Syntax: **mshift_u16**(values, nbits, left_or_right)

Description: Compute the bitwise shifting considering “values” as an ARRAY of 16-bits unsigned integers. “nbits” is the number of bits to shift and “left_or_right” is the direction (0 for left shifting, 1 for right shifting). It returns the shifted ARRAY or a NULL ARRAY in case of an error (the text attribute contains the reason).

Example:

```
[ready]: a = 1::2#3::4
[ready]: a
     1.00000,     2.00000
     3.00000,     4.00000

[ready]: mshift_u16(a, 1, 0)
     2.00000,     4.00000
     6.00000,     8.00000

[ready]:
```

mshift_u32 *Bitwise shifting (32-bits unsigned integer)*

Syntax: **mshift_u32**(values, nbits, left_or_right)

Description: Compute the bitwise shifting considering “values” as an ARRAY of 32-bits unsigned integers. “nbits” is the number of bits to shift and “left_or_right” is the direction (0 for left shifting, 1 for right shifting). It returns the shifted ARRAY or a NULL ARRAY in case of an error (the text attribute contains the reason).

Example:

```
[ready]: a = 1::2#3::4
[ready]: a
     1.00000,     2.00000
     3.00000,     4.00000

[ready]: mshift_u32(a, 1, 0)
     2.00000,     4.00000
     6.00000,     8.00000

[ready]:
```

Mtype *Returns type of array*

Syntax: **Mtype**(a)

Description: Returns zero if a is a real array, and one if it is a complex array.

- N -

nan_index *Index of all NaN elements*

Syntax: **nan_index**(a)

ncaddvar *NetCDF Add Variable*

Syntax: **ncaddvar**($fname,$varname,$vardims)

Description: Adds a new variable to an existing NetCDF file. The variable must use existing dimensions from the NetCDF file, and specify them in order in $vardims .

Example: The following demonstrates the process. The example NetCDF file has 3 dimensions: plane, lat, and lon.

```
[ready]: status = ncaddvar("temp.nc","mydata","plane\nlat\nlon\n"
[ready]: status = ncaddvar("temp.nc","planeinfo","plane\n")
```

ncinq *NetCDF File Inquiry*

Syntax: **ncinq($fname)**

Description: Returns size and shape of NetCDF file $fname in a 1x 4 array, and a list of the variable names in the file. The format of the array is: Number of dimensions:: Number of variables:: Number of Global attributes:: The unlimited Dimension ID (if any). These numbers come directly from call to NetCDF library function 'nc_inq_var'. The .text portion of the return variable will contain a list of the variable names from the file, separated by newlines .

Example: The following demonstrates the process. The example NetCDF file has 3 dimensions, 4 variables, no global attributes, and no variables with an unlimited dimension.

```
[ready]: netcdfinfo = ncinq("temp.nc")
[ready]: netcdfinfo
(10^0) X
row 0 =
  3.00   4.00   0.00  -1.00
[ready]: netcdfinfo.text
Longitude
Latitude
Depth
temperature
```

ncinqvar NetCDF Variable Inquiry

Syntax: **ncinqvar($fname,$varname)**

Description: Returns the size and shape of variable **$varname** within NetCDF file **$fname** in a 1xN array, where N is the number of dimensions of the requested variable. The format of the array is: Size of dimension#1::Size of dimension#2::Size of dimension#3::…::Size of dimension#N. The text portion of the return variable will contain a list of the N dimension names the variable makes use of.

Example: The following demonstrates the process.

```
[ready]: varinfo = ncinqvar("temp.nc","Temperature")
[ready]: varinfo
(10^0) X
row 0 =
34.00 51.00 51.00
[ready]: varinfo.text
Depth
Latitude
Longitude
```

ncnew Create new NetCDF file

Syntax: **ncnew**($fname,$dims,varinfo,$varname)

Description: Creates a new NetCDF file. Parameter **$fname** is the filename to use. The parameter **$dims** should contain the list of dimension names for the new file separated by newlines. The **varinfo** parameter should match the **$dims** variable and provide the size for each respective dimension. Finally, **$varname** should contain the NetCDF variable name to create in the new file. Currently, MSHELL will only create a single variable NetCDF file.

Example: The following demonstrates the process. A new file called newfile.nc is created with two dimensions called dim1, and dim2. A 100x100 variable using these two dimensions is created called myvariable.

```
[ready]: ncnew("newfile.nc","dim1\ndim2",100::100,"myvariable")
0
```

ncols Number of Columns

Syntax: **ncols**(a) or a.**ncols**

Description: Returns the number of columns in the input array.

Example: The following demonstrates the process.

```
[ready]: a = (0,255,1,10356) create 10357x256 matrix
[ready]: ncols(a)
    256
[ready]: a.ncols            // this is an equivalent command
256
```

ncread NetCDF Variable reader

Syntax: **ncread**($fname, $varname) or **ncread**($fname,$varname,start,edges)

Description: Returns the data from a NetCDF variable **$varname** from **$fname**. The first form reads in the entire variable. The second form allows an N-dimensional region of interest to be read from the variable. The **start** variable gives the start position for each dimension of the variable. The **edges** variable gives the length of each of the dimension to read.

Example: The following demonstrates the process. The MSHELL variable **img** will contain 51 rows and 51 columns from the first "plane" of the variable "Temperature". MSHELL arrays storing more than one "plane" will be filled sequentially with each plane requested.

```
[ready]: img = ncread("temp.nc","Temperature",0::0::0,1::51::51)
[ready]: show img
--- img ---
data type is      : real
number of rows    = 51
number of columns = 51
maximum value     = 28.833
minimum value     = -1e+034
```

ncvarattstr NetCDF Variable Attribute String

Syntax: **ncvarattstr**($fname,$varname,$attname)

Description: Returns the contents of the attribute **$attname** attached to variable **$varname** from NetCDF file **$fname** as a string. An error will occur if the variable does not exist. A blank string will be returned if the attribute does not exist.

Example: The following demonstrates the process.

```
[ready]: ncvarattstr("temp.nc","Temperature","units")
degC
```

ncvarattval NetCDF Variable Attribute Value

Syntax:

Description: Returns the value of the attribute **$attname** attached to variable **$varname** from NetCDF file **$fname** as an array. An error will occur if the variable does not exist. A blank string will be returned if the attribute does not exist. Returns a Null string if attribute contains an unknown numeric type.

Example: The following demonstrates the process.

```
[ready]: ncvarattval("temp.nc","Temperature","dtgymd")
19981012
```

ncwrite NetCDF Write Variable

Syntax: **ncwrite**($fname,$varname,img,ncstart,ncedges)

Description: Writes array **img** to an existing variable **$varname** in NetCDF file **$fname**. The parameters **ncstart** and **ncedges** determine what position to start writing in the variable, and how much to write in each dimension. For an N dimensional NetCDF variable, ncstart and ncedges must be 1xN.

Example: The following demonstrates the process. The values 1::2::3 are written to the beginning of the first row in the 2-D variable "myvariable" in NetCDF file "temp.nc".

```
[ready]: ncwrite("newfile.nc","myvariable",1::2::3,0::0,1::3)
0
```

ncwriteatt — *NetCDF Write Attribute*

Syntax: **ncwriteatt**($fname,$varname,$attname,value)or
ncwriteatt($fname,$varname,$attname,$strvalue)

Description: Creates or modifies the value of attribute $attname associated with variable $varname. If $varname is empty string, the attribute is added to the "global" attributes of the NetCDF file. A floating point value (value), or a string ($strvalue) can be written.

.

Example: The following will demonstrates the process.

```
[ready]: ncwriteatt("newfile.nc","myvariable","version",3)
0
[ready]: ncwriteatt("newfile.nc","myvariable","Units","degrees C")
```

neqindex — *Non-Equality Index*

Syntax: **neqindex(a,b)**

Description: Finds the locations of all the elements in an input array which are not equal to a constant value, where 'a' is the input array and 'b' is the constant scalar quantity. This function returns a (1 x M) complex array, where M is the number of points not equal to the specified value and whose array elements contain the coordinates of each point encoded as follows: the real part contains the column index, and the imaginary. part contains row index of the point. If all elements are matched, a null value is returned.

Example: The following MSHELL statement will compute the….

```
[ready]: moe = 1#2#3
[ready]: neqindex(moe,1)
row0 =   0.00+  1.00i   0.00+  2.00i
```

nint *Nearest Integer*

Syntax: **nint**(a) or a.**nint**

Description: Compute the nearest integer for each element in the array.

Example: The following MSHELL statement will compute the nearest integer for each element of the input array, 'a', and store the result in 'c'.

```
[ready]: a = randu(2,4) // create a random 2x4 matrix
[ready]: nint(a)
row 0 =
  0.00   1.00   1.00   0.00
row 1 =
  1.00   1.00   0.00   0.00
```

nlines *Returns number of Lines*

Syntax: **nlines**($string)

Description: This function returns the number of lines contained in the string "$string".

not_finite_index *Index of all infinite elements*

Syntax: **not_finite_index**(a)

Description: This function locates all the infinite elements of variable *a* and returns a (1 x M) complex array (*M* is the number of infinite values found in *a*) whose elements contain the coordinates of each point encoded as follows: the real part contains the column index, and the imaginary part contains row index of the point. If no elements are matched, a NULL array is returned.

See Also: **finite_index**

nrows *Number of Rows*

Syntax: **nrows**(a) or a.**nrows**

Description: Returns the number of rows in the input array.

Example: The following demonstrates the process.

```
[ready]: a = (0,255,1,10356)    //create 10357x256 matrix
[ready]: nrows(a)
    10356
[ready]: a.nrows            // this command is equivalent
    10356
```

- O -

---

ones *Initialize an Array to all ones*

Syntax: **ones**(n,m)

Description: Create an array of the specified dimensions, with all elements set equal to 1.

Example: The following MSHELL statement will create a 512 x 512 array with all entries set to 1,

```
[ready]:a = ones(512,512)
[ready]: a(300,0:4) // print first 5 elements in row 301
row 0 =
  1.00   1.00   1.00   1.00   1.00
```

---

openf *Open a file for Formatted I/O*

Syntax: **openf**(unit,"fname","mode")

Description: This function is used to open a disk file for formatted input or output. The unit number can be any positive integer value. The selected integer value will identify the opened file from then on. The file name, “fname” must be a valid file name in DOS. The “mode” string must be one of the followings: "r" for read; "w" for write; or "a" for append.

If the write or append modes are tried on a non-existing file, the file will be created. The **openf** returns a 0 into status if successful. The system variable **M_path** will determine which directories, in addition to the current directory, to be searched.

If ‘fname’ contains any environment variables in the form ‘$(VAR)’, those are expanded to their values (see “expand” command).

See Also: **writef readlinef** and **closef**

Example: The following will open "test.out" for output as unit number 1, and "test.in" for input as unit number 2,

```
[ready]: status = openf(1,"test.out","w");
[ready]: status = openf(2,"test.in","r");
```

- P -

pause Suspend Execution for N Seconds

Syntax: **pause**(N)

Description: Will causes MSHELL to stop execution for 'N' seconds. If the value of 'N' is negative a pause dialog box will be opened. Note that 'N' can be a fractional number of seconds.

pds_close Close a handle to a previously opened PDS file

Syntax: **pds_close**(hdl)

Description: This command closes the handle *hdl* associated to a previously opened PDS file.

pds_get_table_column Returns values of specified table column

Syntax: **pds_get_table_column** (hdl, $colname)

Description: This command works after a call to the *pds_open* command. It returns all the ARRAY values associated to the specified table column name as a row vector.

pds_get_table_string_column Returns string values of specified table column

Syntax: **pds_get_table_string_column** (hdl, $colname)

Description: This command works after a call to the *pds_open* command. It returns all the string values associated to the specified table column name as a multiple lines string variable.

pds_open Return a handle to the opened PDS file

Syntax: **pds_open**($fname, $iomode)

Description: This command attempts to open a PDS file specified by $fname in read mode ($iomode = "r") or read/write mode ($iomode = "w") and returns a handle to the opened file. $fname must be a "/" separated path ("\" is not supported under Windows either).

pdsfindobj Get a list of objects within a PDS file

Syntax: **pdsfindobj**($fname)

Description: Returns the name of each PDS object found in $fname. Object examples would be IMAGE, or BROWSE_IMAGE.

pdskwdstr Retrieve a PDS keyword value

Syntax: **pdskwdstr**($label_string, $kwd_name)

Description: Returns the value of the PDS keyword specified in $kwd_name if found in the complete PDS label $label_string.

Example: The following MSHELL code will retrieve two keywords from a PDS file.

```
[ready]: eqohare = reada("C:/PROVIEW/IMAGES/eqohare.pds","pds")
[ready]: $hdr = eqohare.text
[ready]: pdskwdstr($hdr, "PDS_VERSION_ID")
PDS3
[ready]: pdskwdstr($hdr, "IMAGE/LINES")
256
```

pdsreadlabel Return the content of a PDS label file

Syntax: **pdsreadlabel** ($pds_lbl_fname)

Description: This command returns the content of the specified PDS label file as a string variable.

pixval Displays Pixel Status of Mouse

Syntax: **pixval**(a)

Description: This displays the pixel value and intensity corresponding with the placement of the mouse when clicked within an image "a" ,after having entered this command at the command line window.

Example: pixval(x)

Now click in the image "x" where you would like placement and intensity status.

The following is returned:

<row position> <column position> <intensity> <button value>

The <button value> is 1 for a left click or 2 for a right click. Also, if the selection is made outside of the image, then the first three values are all -1.

plankeq *Compute the black body radiation (Plank's Equation)*

Syntax: **bbody = plankeq** (wavelengths, temperatures)

Description: This command returns the black body electromagnetic radiation at the specified wavelengths and temperatures following the Plank's equation:

wavelengths can be either a scalar or a column vector and *temperatures* can be either a scalar or a row vector. If the wavelengths are *W* and the temperatures are *T* the result is a matrix *WxT*.

plot *Plot a Vector*

Syntax: **plot**[#](y) or **plot**[#](x,y)

Description: Plots a row vector. The parameter '#' in the plot function is an optional integer (0 to 255) that selects the plot screen where the plot will be placed. If an integer number from 0 to 255 is provided in this field, the generated plot can be indexed from then on by that number. For example if 'x' is a row vector, then **plot**10(x); will plot the vector on plot screen number 10. If you would like to free that screen later on you can type **free plot**10. Note that the plot function can have either one or two arguments.

Single Argument Case: When one argument is used in the plot function as in **plot**(y), the row vector 'y' will be plotted against an internally generated ramp of integer values. If 'y' is a complex vector then the real part of 'y' will be used as the abscissa and the imaginary part of 'y' as the ordinate.

Two Argument Case: When two arguments are used with the plot function, as in **plot**(x,y); the first argument, 'x' , corresponds to the abscissa values and the second argument, 'y', corresponds to the ordinate values, i.e. a plot of 'y' versus 'x' will result. Hence, for the case that 'y' is complex, **plot**(y), is equivalent to **plot**(**real**(y), **imag**(y)).

See Also: **"M_"** for a complete list of system variables which affect the plot function.

Example: The following MSHELL instructions generate two ramp vectors in memory, 'x' and 'y', and plot **sin**(y) as a function of **cos**(x); see Figure below and code following.

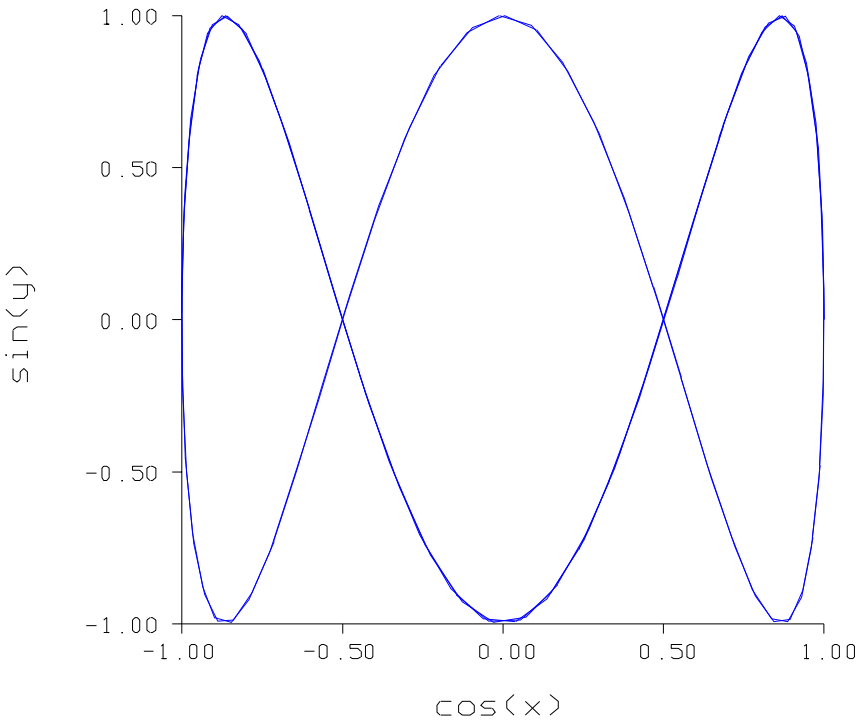


Figure 5

```
[ready]: x = (0,3.14159*5,0.1);
[ready]: y = 3.0 * x ;
[ready]: M_ylabel = "sin(y)";
[ready]: M_xlabel = "cos(x)"
[ready]: plot(sin(y),cos(x));
```

---

plot_axis_scale — *Set the scale for a plot axis*

Syntax: **plot_axis_scale**(idPlot, $axis, min, max, step)

Description: Sets the scale for an axis of the specified plot in ACT-REACT MDI. The axis the new scale is applied to is specified with *$axis*. *$axis* can have one of the following values: **xBottom**, **xTop**, **yLeft**, **yRight** (currently only xBottom and yLeft are supported). *step* is the step size of the axis ticks. If *step* is set to 0 then the step size is automatically computed.

---

plot_clear — *Clear a plot*

Syntax: **plot_clear**(idPlot)

Description: Clear the specified plot in ACT-REACT MDI removing all curves in it.

plot_wclose — *Close a plot window*

Syntax: **plot_wclose**(idPlot)

Description: Closes the window of the specified plot in ACT-REACT MDI.

See also: **plot_wclose_all**

plot_wclose_all — *Close all plot windows*

Syntax: **plot_wclose_all**()

Description: Closes all plot windows in ACT-REACT MDI.

See also: **plot_wclose**

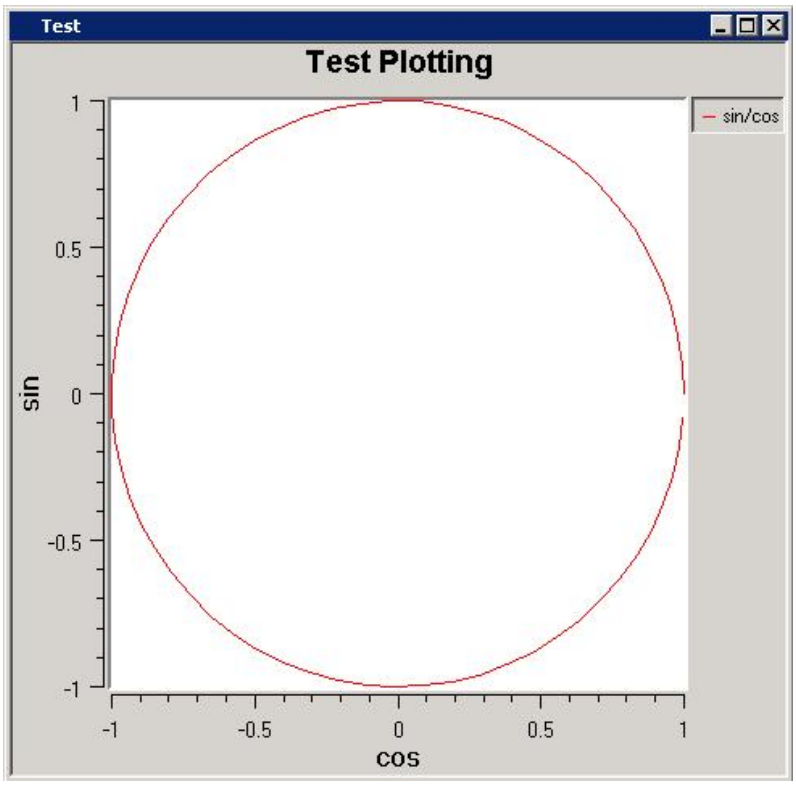
plot_curve_data — *Plot a data curve*

Syntax: **plot_curve_data**(idPlot, idCurve, x, y)

Description: Similar to **plot_data**. This function allows to change *x*,*y* values of the specified curve in the specified plot. *x* and *y* are one row vectors. They must have the same number of columns.

See also: **plot _data, plot_curve_style, plot_curve_symbol**

Example: The following example shows how to set up a plot and curves using user provided ids




```
// force the creation of a plot with a given id
id = 0
plot_open(id, "Test Plotting")

// set up the plot
...

// initialize data
i = 0
while( i <= 2*pi ){
                    if( i == 0 ){
                        x = cos(i)
                        y = sin(i)
                    }else{
                        x = x::cos(i)
                        y = y::sin(i)
                    }
                    i += 0.1
}

// force the creation of a curve with a given id
idCurve = 0
plot_curve_open(id, idCurve, "sin/cos")
// plot data
plot_curve_data(id, idCurve, x, y)
```

plot_curve_hide — *Hide a curve*

Syntax: **plot_curve_hide**(idPlot, idCurve)

Description: Hides the specified curve of the specified plot in ACT-REACT MDI.

See also: **plot_curve_show**

plot_curve_label — *Set the name of a plot curve*

Syntax: **plot_curve_label**(idPlot, idCurve, $curveName)

Description: This function allows to set the name of the specified curve in the specified ACT-REACT MDI plot.

See also: **plot _data, plot_curve_new, plot_curve_open**

plot_curve_new — *Create a new curve*

Syntax: **plot_curve_new**(idPlot, $curveName)

Description: This function allows to create a new curve in the specified ACT-REACT MDI plot. It returns the id of the new curve created. The name of the curve is set to *$curveName*. If *$curveName* is empty then a default name will be used.

See also: **plot _data, plot_curve_open**

plot_curve_open — *Create a curve with a custom id*

Syntax: **plot_curve_open**(idPlot, idCurve, $curveName)

Description: This function allows to create a new curve with a user provided id. The name of the curve is set to *$curveName.* If *$curveName* is empty then a default name will be used. If the *idCurve* belongs to an existing curve, then nothing is done.

See also: **plot _data, plot_curve_new**

Example: see plot_curve_data example.

plot_curve_remove — *Remove a curve*

Syntax: **plot_curve_remove**(idPlot, idCurve)

Description: Deletes the specified curve from the specified ACT-REACT MDI plot.

plot_curve_show — *Show a curve*

Syntax: **plot_curve_show**(idPlot, idCurve)

Description: Shows the specified curve in the specified ACT-REACT MDI plot.

See also: **plot_curve_hide**

plot_curve_style — *Change the style of a curve*

Syntax: **plot_curve_style**(idPlot, idCurve, $style)

Description: This function allows to change the style of the specified curve in the specified ACT-REACT MDI plot. Possible styles are:

Style	Description
NoCurve	Don't draw a curve
Lines	Connect the points with straight lines
Sticks	Draw vertical sticks
Steps	Connect the points with a step from the left to the right
Dots	Draw dots at the locations of the data points

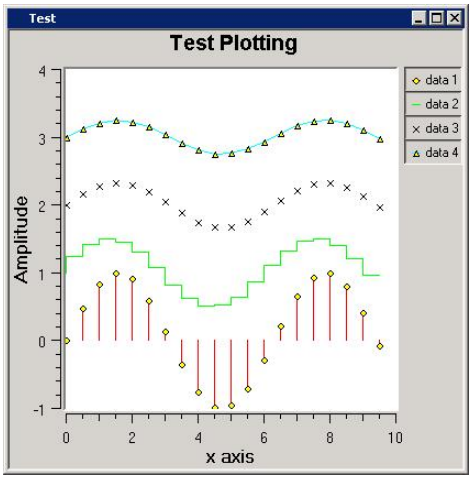
Example: see plot_curve_symbol example.

plot_curve_symbol — *Change the symbol for curve points*

Syntax: **plot_curve_symbol**(idPlot, idCurve, $symbol)

Description: This function allows to change the symbol for points of the specified curve in the specified ACT-REACT MDI plot. Possible symbols are: **NoSymbol**, **Ellipse**, **Rect**, **Diamond**, **Triangle**, **DTriangle**, **UTriangle**, **LTriangle**, **RTriangle**, **Cross**, **XCross**, **HLine**, **VLine**, **Star1**, **Star2**, **Hexagon**.

Example: The following example shows how to change curve styles and symbols




```
// set up a plot
...

// initialize data
x = 0
y = 0
val = 0
while( val < 10 ){
                    x = x::val
                    y = y::sin(val)
                    val = val + 0.5
}

// plot data
idCurve1 = plot_data(id, x, y, "data 1")
idCurve2 = plot_data(id, x, y/2 + 1, "data 2")
idCurve3 = plot_data(id, x, y/3 + 2, "data 3")
idCurve4 = plot_data(id, x, y/4 + 3, "data 4")

// change curve style
plot_curve_style( id, idCurve1, "Sticks")
plot_curve_style( id, idCurve2, "Steps")
plot_curve_style( id, idCurve3, "NoCurve")

// change curve symbol
plot_curve_symbol( id, idCurve1, "Ellipse")
plot_curve_symbol( id, idCurve3, "XCross")
plot_curve_symbol( id, idCurve4, "Triangle")
```

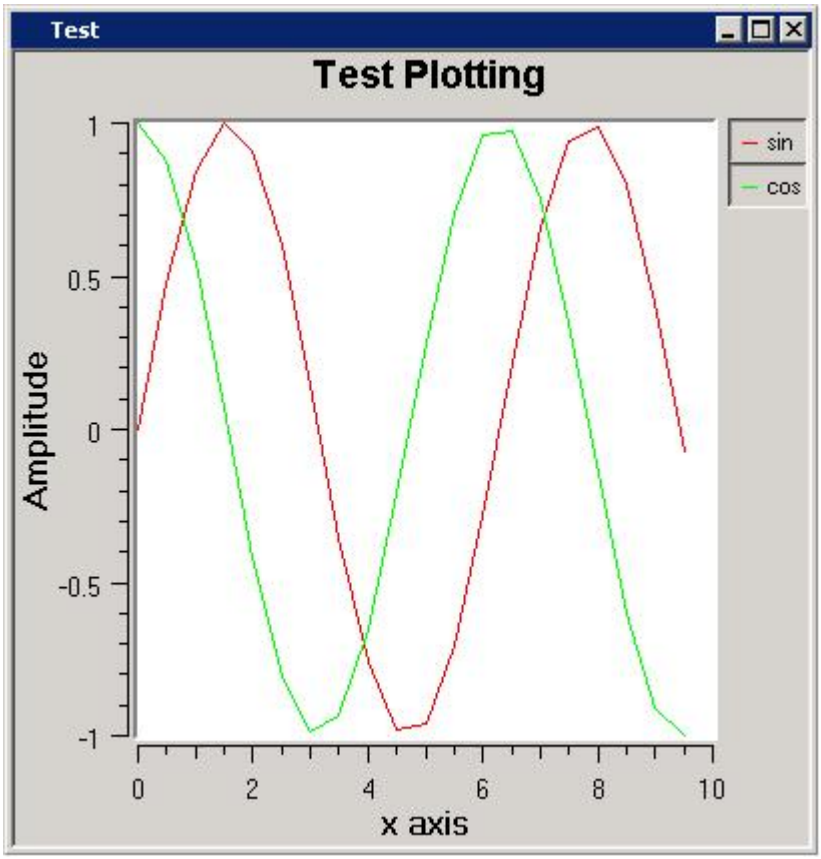
plot_data — *Plot a new data curve*

Syntax: **plot_data**(idPlot, x, y, $curveName)

Description: This function allows to plot a new curve in the specified plot. *x* and *y* are one row vectors. They must have the same number of columns. By default all points defined by *x*,*y* vectors are connected with lines. It is possible to change this behavior using the **plot_curve_style** function to change the curve style. Furthermore it is possible to define the symbol for each point in the plot using the **plot_curve_symbol** function. Points whose coordinates are ***nan*** are not plotted, while ***inf*** values are regularly put into the plot. The name of the new curve created is set to *$curveName.* If *$curveName* is empty then a default name is used. The functions returns the id of the new curve created.

See also: **plot_curve_data, plot_curve_style, plot_curve_symbol**

Example: The following example shows how to simply set up a plot and plot some data



```
// initialize data
x = ones(1, 20)
y1 = ones(1, 20)
y2 = ones(1, 20)
i = 0
val = 0
while( i < 20 ){
                    x(0, i) = val
                    y1(0, i) = sin(val)
                    y2(0, i) = cos(val)
                    val = val + 0.5
                    i = i + 1
}

// create the new plot
id = plot_new("Test Plotting")

// view the plot
plot_view(id)

// set the plot window title
plot_wtitle(id, "Test")

// set the plot label
plot_xlabel(id, "x axis")
plot_ylabel(id, "Amplitude")

// plot data
idCurve1 = plot_data(id, x, y1, "sin")
idCurve2 = plot_data(id, x, y2, "cos")
```

plot_exists — *Check whether a plot id is valid*

Syntax: **plot_exists**(idPlot)

Description: This function allows to verify whether the id of a plot is valid. It returns 1 if the plot id is valid, otherwise it returns 0.

plot_free — *Remove a plot from memory*

Syntax: **plot_free**(idPlot)

Description: Removes the specified ACT-REACT MDI plot from memory

See also: **plot_free_all**

plot_free_all — *Remove all plots from memory*

Syntax: **plot_free_all**()

Description: Removes all ACT-REACT MDI plots from memory

See also: **plot_free**

plot_get_list — *Return the list of plots in memory*

Syntax: **plot_get_list**()

Description: This functions returns the list of plot ids in ACT-REACT MDI.

plot_new — *Create a new plot*

Syntax: **plot_new**($plotTitle)

Description: This functions allows to create a new plot in ACT-REACT MDI. The plot title will be set to *$plotTitle* or to a default title if it is empty. The function returns the id of the new plot created.

See also: **plot_open**

Example: see plot_data example.

plot_open — *Create a new plot with a custom id*

Syntax: **plot_open**(idPlot, $plotTitle)

Description: This functions allows to create a plot with a user provided id in ACT-REACT MDI. If a plot with the id specified already exists, then that plot is cleared. The plot title will be set to *$plotTitle* or to a default title if it is empty.

See also: **plot_new**

Example: see plot_curve_data example.

plot_save — *Save an image file for the current plot*

Syntax: **plot_save**(idPlot, $filename, width, height)

Description: This functions allows to save an image for the specified plot. The dimension of the image in pixels is specified by *width* and *height*. *width* or *height* can be set to zero, in such case the dimension of the image will be set to the current plot dimension.

---

plot_title — *Set the title for a plot*

Syntax: **plot_title**(idPlot, $title)

Description: Sets the title of the specified plot in ACT-REACT MDI.

See also: **plot_wtitle**

Example: see plot_data example

---

plot_view — *Show a plot*

Syntax: **plot_view**(idPlot)

Description: Shows the plot with the specified id in the in ACT-REACT MDI.

See also: **plot_view_all**

Example: see plot_data example

---

plot_view_all — *Show all plots*

Syntax: **plot_view_all**()

Description: Shows all plots in ACT-REACT MDI.

See also: **plot_view**

---

plot_wtitle — *Set the title for the window of a plot*

Syntax: **plot_wtitle**(idPlot, $title)

Description: Sets the title of the window of the specified plot in ACT-REACT MDI.

See also: **plot_title**

Example: see plot_data example

plot_xlabel — *Set the label for plot x axis*

Syntax: **plot_xlabel**(idPlot, $xLabel)

Description: Sets the label for the x axis of the specified plot in ACT-REACT MDI.

See also: **plot_ylabel**

Example: see plot_data example

plot_ylabel — *Set the label for plot y axis*

Syntax: **plot_ylabel**(idPlot, $yLabel)

Description: Sets the label for the y axis of the specified plot in ACT-REACT MDI.

See also: **plot_xlabel**

Example: see plot_data example

plot3d — *3-D Plot or Mesh Plot*

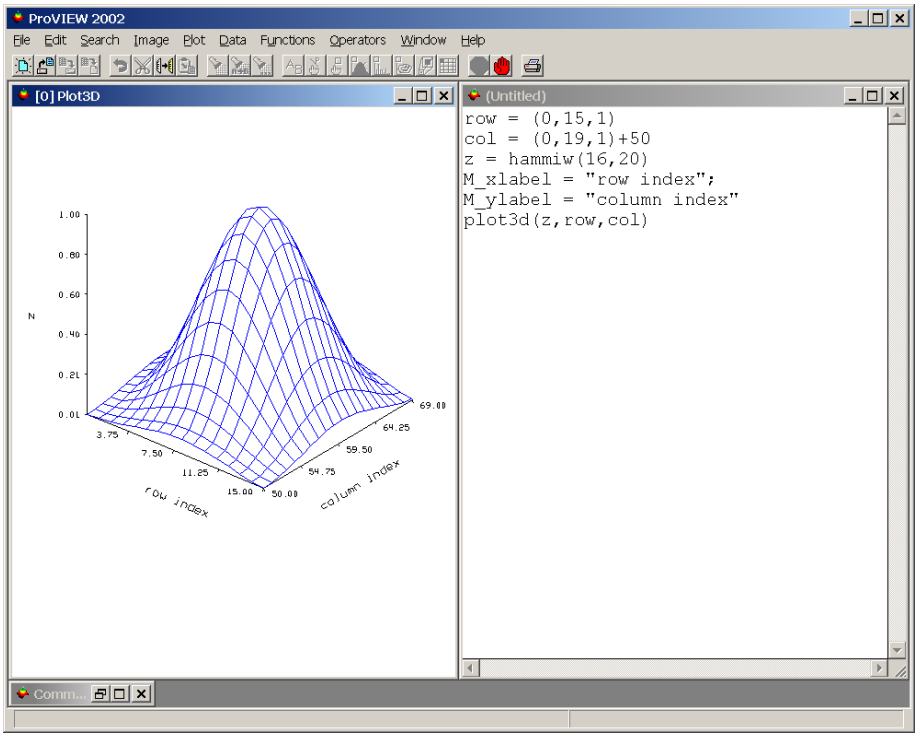
Syntax: **plot3d**[#](z) [presently only supported in the web based interface to mshell]

Description: This function generates a hidden line surface plot using the values of an input array, **'z'.** The **plot3d** function requires as arguments a real array, 'z', with two or more rows, and two or more columns. You can also provide a row and column axis vector for annotation. The parameter '**#**' in the plot function is an optional integer (0 to 255) that selects the plot screen where the plot will be placed. If an integer number from 0 to 255 is provided in this field, the generated plot can be indexed from then on by that number For example if 'x' is an array, then **plot3d**10(x) will plot 'x' on plot screen number 10. If you want to free that screen later on you can type **free plot**10.

See Also: "M_ for a complete list of system variables which affect the plot functions.

Example: The following MSHELL instructions generate a 32 x 32 Hamming function and displays the function as a 3d plot.

```
row = (0,15,1)
col = (0,19,1)+50
z = hammiw(16,20)
M_xlabel = "row index";
M_ylabel = "column index"
plot3d(z,row,col)
```



polyfill *Fills an Image with Polygons*

Syntax: **list = polyfill(image, complex(value,fill)::polylist)**

Description: Fills and Image with Contained Polygons. This routine allows for the fast drawing of polygons on '**image**'. '**polylist**' is a complex array where each row correspond to a polygon. Each element in polylist is a complex number with row and column position. The column number is encoded as the real part and the row number as the imaginary part.
Image. 'value' is a column vector containing the real amplitude values to assign to the polygon to be drawn. 'fill is a flag vector that determines if the polygon will be drawn or not. The values of fill must be zero or one.

.

Example: The following MSHELL expression illustrates the use of the polyfill function**.**

```
fill                = ones(3,1)*1
value               = (255::128::64)'
image               = zeros(256,256)
polylist= complex(0::100::150::0,0::0::100::100)

polylistm = (polylist#(polylist*1.5)#(polylist*2))
polylistm = rmirror(polylistm)

control = complex(value,fill)::polylistm
out                 = polyfill(image,control )

view                image
out
```

polygonorient — *Computes the orientation of a polygon*

Syntax: result = polygonorient(poly)

Description: This function computes the orientation of a generic polygon, given the coordinates of its vertices. The coordinates are specified as a complex row vector. The polygon is not required to be closed, so the last vertex can be different from the first one (see the example below.). This command works only with simple polygons, i.e. polygons not interecting themselves or having holes. Note: in case the polygon is convex consider use the faster **convpolygonorient** command.

Return values:

0 The given polygon is degenerate

1 Means Clock-Wise orientation (CW)

-1 Means Counter-Clock-Wise orientation (CCW)

See Also: convpolygonorient

Example:

```
// clock-wise polygon:

a=complex(0,0)::complex(0,10)::complex(10,10)::complex(10,0)
s = polygonorient(a)

s // s == 1
```

preg_match — *Regular Expression Matching*

Syntax: preg_match($str_to_search, $regular_expression_pattern)

Description: Given a regular expression pattern, this function finds **the first match** in the input string.

General documentation on using regular expressions can be found here:
http://www.perldoc.com/perl5.8.0/pod/perlre.html

See also preg_replace

Example: The following MSHELL expression illustrates the use of the regulars expression capabilities. Given the following code,

```
$a = "moe\nTEMP_MAX,IMG_MAX,IMG_MIN,IMG_MEAN,MOE,LARRY,CURLY"
b = preg_match($a,"IMG_([^,]+),")

print "input string:\n"::$a::"\n"

print "\noutput of preg_match, i.e. b.text\n"::b.text::"\n"

print "\noutput of preg_match, i.e. b\n"::float2str(b,"%.0f")::"\n"
```

once executed it generates,

```
input string:
moe
TEMP_MAX,IMG_MAX,IMG_MIN,IMG_MEAN,MOE,LARRY,CURLY

output of preg_match, i.e. b.text
IMG_MAX,
MAX


output of preg_match, i.e. b
13,21
17,20
```

Row 0 of b contains the start and end position of the first occurrence of the pattern. Subsequent rows will contain any “captured substrings” called out in the pattern with ()’s.

Note: end position is returned as one character beyond the match found, a convenient start position value to use to continue search of rest of input string.

Also, b.text will contain the all the substrings specified in b, one per line.

The following provides additional examples. By no means this is a complete set of examples.

```
$a =
"moe\ntesting\nTEMP_MAX,IMG_MAX,IMG_MIN,IMG_MEAN,MOE,LARRY,LARBA,TEEEMP
_MAX,CURLY"

print "\n\n"

print "-----------------EXAMPLE of Using Anchors --------------------
\n"
print "Note: Anchor are used to limit a match to a particualr location
in the string, \n"
print "                 ^   for the start of the string\n"
print "                 $   for the end of the string\n"


print "a '^'  at the beginning of a string means that it must match the
beginning of the string\n"
$pattern  = "^mo"
b= preg_match($a,$pattern)
print "INPUT STRING:\n"::$a::"\n"
print "SEARCH PATTERN is: "::$pattern::"\n"
print "\nOUTPUT of preg_match, i.e. b.text\n"::b.text::"\n"
print "\nOUTPUT of preg_match, i.e. b\n"::float2str(b,"%.0f")::"\n"

print "Note: a '$'  at the end of the regular expression string means
that it must match the end of the string\n"
$pattern = "(?m)ing$"   // use (?m) to activate inline option to use ^
to match after and  $ to match before internal new lines
b= preg_match($a,$pattern)
print "INPUT STRING:\n"::$a::"\n"
print "SEARCH PATTERN is: "::$pattern::"\n"
print "\nOUTPUT of preg_match, i.e. b.text\n"::b.text::"\n"
print "\nOUTPUT of preg_match, i.e. b\n"::float2str(b,"%.0f")::"\n"



print "-----------------EXAMPLE of character classes ------------------
--\n"
print "Note: all characters within a [] are treated as a set of
acceptable characters\n"
$pattern = "LAR[AB]"
b= preg_match($a,$pattern)
print "INPUT STRING:\n"::$a::"\n"
print "SEARCH PATTERN is: "::$pattern::"\n"
print "\nOUTPUT of preg_match, i.e. b.text\n"::b.text::"\n"
print "\nOUTPUT of preg_match, i.e. b\n"::float2str(b,"%.0f")::"\n"
$pattern = "M[A-E]+N"   // allow in the class  A or B or C or D or E
b= preg_match($a,$pattern)
print "INPUT STRING:\n"::$a::"\n"
print "SEARCH PATTERN is: "::$pattern::"\n"
print "\nOUTPUT of preg_match, i.e. b.text\n"::b.text::"\n"
print "\nOUTPUT of preg_match, i.e. b\n"::float2str(b,"%.0f")::"\n"
```

```
print "-----------------EXAMPLE of repeating sequences ----------------
----\n"
print "Note: repeating sequences are specified by the regular
expression quantifiers\n, i.e.\n"
print "                ?   specifies 0 or 1 \n"
print "                *   specifies 0 or more \n"
print "                +   specifies 1 or more\n"
print "                {n} specifies exactly n times\n"
print "                {n,m}   specifies at least n, no more than m
times \n"
print "                {n,}    specifies at least n times \n"
$pattern = "LAR[AB]+"
b= preg_match($a,$pattern)
print "INPUT STRING:\n"::$a::"\n"
print "SEARCH PATTERN is: "::$pattern::"\n"
print "\nOUTPUT of preg_match, i.e. b.text\n"::b.text::"\n"
print "\nOUTPUT of preg_match, i.e. b\n"::float2str(b,"%.0f")::"\n"

$pattern = "T(E{3,})MP"
b= preg_match($a,$pattern)
print "INPUT STRING:\n"::$a::"\n"
print "SEARCH PATTERN is: "::$pattern::"\n"
print "\nOUTPUT of preg_match, i.e. b.text\n"::b.text::"\n"
print "\nOUTPUT of preg_match, i.e. b\n"::float2str(b,"%.0f")::"\n"


$pattern = "IMG_([^,]+),"
// the above pattern is looking for IMG_ followed by one or more non-
commas characters and then a comma
b = preg_match($a,$pattern)
print "INPUT STRING:\n"::$a::"\n"
print "SEARCH PATTERN is: "::$pattern::"\n"
print "\nOUTPUT of preg_match, i.e. b.text\n"::b.text::"\n"
print "\nOUTPUT of preg_match, i.e. b\n"::float2str(b,"%.0f")::"\n"

print "Note: a '$'  at the end of the regular expression string means
that it must match the end of the string\n"
$pattern = "(?m)^.*ing$"    // use (?m) to activate inline option to
use ^ to match after and  $ to match before internal new lines
b= preg_match($a,$pattern)
print "INPUT STRING:\n"::$a::"\n"
print "SEARCH PATTERN is: "::$pattern::"\n"
print "\nOUTPUT of preg_match, i.e. b.text\n"::b.text::"\n"
print "\nOUTPUT of preg_match, i.e. b\n"::float2str(b,"%.0f")::"\n"




print "Note: a '$'  at the end of the regular expression string means
that it must match the end of the string\n"
$a = "Hi, I am 44 years old, and I can do 45 push-ups in 3 seconds."
```

```
$pattern = "([0-9]+) years old.*?([0-9]+) push-ups.*?([0-9]+) seconds"
                    // use (?m) to activate inline option to use ^ to
match after and  $ to match before internal new lines
b= preg_match($a,$pattern)
print "INPUT STRING:\n"::$a::"\n"
print "SEARCH PATTERN is: "::$pattern::"\n"
print "\nOUTPUT of preg_match, i.e. b.text\n"::b.text::"\n"
print "\nOUTPUT of preg_match, i.e. b\n"::float2str(b,"%.0f")::"\n"
```

preg_replace *Regular Expression Replace*

Syntax: preg_replace($str_to_search, $regular_expression_pattern, $replacement_expression)

Description: Regular expression string replace support

Example: The following MSHELL expression illustrates the use of the regulars expression capabilities

```
$a = "Fred Flintstone\nBarney Rubble\nWilma Flintstone\nBetty Rubble\n"
"----"
$a
"----"
$c = preg_replace($a,"(\\w)\\w* (\\w+)","$1 $2")
$c
"----"



----
Fred Flintstone
Barney Rubble
Wilma Flintstone
Betty Rubble

----
F Flintstone
B Rubble
W Flintstone
B Rubble

----
```

General documentation on using regular expressions can be found here:
http://www.perldoc.com/perl5.8.0/pod/perlre.html

These functions are based on the "Perl Compatible Regular Expressions" library (PCRE). Information on PCRE can be found at: **http://www.pcre.org/**. The topics in the PCRE manual pages on usage of regular expressions within the C API are applicable to the MSHELL functions which make use of them.

print *Formatted Print*

Syntax: **print** "..."

Description: Prints scalar values or strings to the standard output.

Example: The following MSHELL expression illustrates the use of the print statement

```
[ready]: M_format = "000.000000"
[ready]: x = 3
[ready]: print "The value of x = " x "\n"
The value of x = 3.000000
```

printdebug *Formatted Print (debug mode)*

Syntax: **printdebug** "..."

Description: This command is similar to the "print" command but it really prints out on the standard output only when M_echo > 5.

proj_latlong_from_proj *Convert to lat/long projection string*

Syntax: **proj_latlong_from_proj**($proj)

Description: Convert the input projection string *$proj* into the lat/long (geographic coordinate) projection string.

putenv *Assign to sys environment variable*

Syntax: **putenv**($assignment)

Description: Assigns an operating system environment variable given an assignment expression in $assignment.

Example: The following MSHELL statement will assign an environment variable

```
[ready]: putenv("MYVAR=value")
[ready]: getenv("MYVAR")
value
```

- Q -

qgauss *Area Under Gaussian Density*

Syntax: **qgauss**(a) or a.**qgauss**

Description: Let Z(x) be the one dimensional Gaussian density function with zero mean and unit variance, defined as

$$Z(x) = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2},$$

then **qgauss** returns the integral of Z(x) from x to infinity,

$$\int_{a_{j,i}}^{\infty} Z(x)dx$$

for each element in the input array.

Example: The following MSHELL expressions compute the area under the Gaussian density function (the probability) for values of 0 to 5 standard deviations.

```
[ready]: sigma = (0,5,0.1)
[ready]: plot(sigma,qgauss(sigma))
```

qgaussinv *Inverse of qgauss*

Syntax: **qgaussinv**(a) or a.**qgaussinv**

Description: Given an input array with values, with 0.0 < $a_{j,i}$ < 1.0 that correspond to probabilities under the normalized Gaussian density function, **qgaussinv** computes the decision threshold values, $t_{j,i}$, that will generate those probability values. That is, **qgaussinv** computes the values of $t_{j,i}$ such that the area under the normalized Gaussian density between $t_{j,i}$ and infinity equals $a_{j,i}$, i.e.

$$a_{j,i} = \int_{t_{j,i}}^{\infty} \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}} dx$$

Example: The following MSHELL expression computes the ordinate values under the Gaussian density function for a row vector with values of 0.25, 0.50, and 0.75.

```
[ready]: qgaussinv( 0.25::0.50::0.75 )
  0.67   0.00  -0.67
```

- R -

---

randg Gaussian Random Number Generator

Syntax: **randg**(n,m)

Description: This function is similar to **randu**, except that it generates independent identically distributed (i.i.d.) Gaussian random numbers with zero mean and unit variance, where, 'n' and 'm' refer to the number of rows and columns in the array of Gaussian random numbers to be generated.

Example: Say, 'a' is an already existing array to which it is desired to add Gaussian distributed random numbers with zero mean and standard deviation of 10. The following MSHELL expression will add the Gaussian noise to 'a' and will save the result in c,

```
[ready]: randinit(30)   //initialize random number generator
[ready]: a = (10,100,1)
[ready]: c = a+10. * randg( a.nrows, a.ncols);
[ready]: plot(a,c)
```

---

randinit Random Number Seed Initializer

Syntax: **randinit**(n)

Description: As this function is used to initialize the MSHELL random number generators it does not return any value. To initialize a random sequence, call **randinit** using a scalar value greater than 1.

Example: The initialization and subsequent use of a random generator,

```
[ready]: randinit(10)       // initialize random number generators
[ready]: x = randg(1,100)   // call gaussian. rand. num. gnrtr
```

---

randu Uniform Random Number Generator

Syntax: **randu**(n, m)

Description: This generator produces independent identically distributed (i.i.d.) random numbers between 0 and 1. It returns a pointer to an (n x m) dimensioned array structure, where n and m are, respectively, the number of rows and columns of uniformly distributed random numbers generated.

The uniform random number generator itself is an adaptation of the **RAN1( )** generator presented in "Numerical Recipes in C", see page 3, "**References and Further Readings**". This is a portable

generator (given the same seed number it will generate the same random sequence on all machines), which utilizes three linear congruential generators in producing output.

Example: The following MSHELL expressions will add uniform noise, with intensities between 0 and 10, to the array, 'a', and save the result in 'c',

```
[ready]: randinit(20)   //initialize random number generator
[ready]: c = a+10. * randu( nrows(a) , ncols(a) )
```

rcoeff *Correlation Coefficient*

Syntax: **rcoeff**(a,b)

Description: Estimates the correlation coefficient between two arrays, 'a' and 'b' with the same dimensions. The correlation coefficient is a scalar. Although the correlation coefficient is an internal function,. it could also be computed in terms of other MSHELL instructions as,

rcoeff(a,b) = (mean(a*.b)-a.mean*b.mean)/sqrt(a.var*b.var) .

react_clear_cvdataprofiler Clear Cartographic Viewer Flexible Data Profiler Panel

Syntax: **react_clear_cvdataprofiler**()

Description: Clear Cartographic Viewer Viewer Flexible Data Profiler panel

react_close_cvdataprofiler Close Cartographic Viewer Flexible Data Profiler Panel

Syntax: **react_close_cvdataprofiler**()

Description: Close Cartographic Viewer Viewer Flexible Data Profiler panel

react_close_dataprofile Close MSHELL MDI Data Profile Panel

Syntax: **react_close_dataprofile**()

Description: Close MSHELL MDI Data Profile panel

react_open_cvdataprofiler Open Cartographic Viewer Flexible Data Profiler Panel

Syntax: **react_open_cvdataprofiler**()

Description: Open Cartographic Viewer Flexible Data Profiler panel

react_get_carto_info Retrieve Cartographic Viewer information

Syntax: **react_get_carto_info**($info_type)

Description: Retrieve Cartographic Viewer information depending on the specified information type string ("$info_type"). If the function call is successful, it returns an ARRAY containing the requested information (both as ARRAY elements and text attribute). In case of an error, it returns a NULL ARRAY and the text attribute contains the error description.

The following "$info_type" strings are allowed:

- "basic"; the returned ARRAY is a row vector ARRAY:
  carto_ULx::carto_ULy::carto_dx::carto_dy::carto_Nx::carto_Ny

- *carto_ULx::carto_ULy* is the upper left corner in cartographic coordinates of the current view in the Cartographic Viewer
- *carto_dx::carto_dy* is the x and y resolution in meters-per-pixel of the current view in the Cartographic Viewer
- *carto_Nx::carto_Ny* is the width and height of the current view in the Cartographic Viewer
- *.text* attribute is set to the map projection string of the current view in the Cartographic Viewer

- "mvp", the returned ARRAY is set to 0 and its *.text* attribute will contain the map view projection of the current view in the Cartographic Viewer.
- Empty string (same as "basic")

---

react_set_carto_map_info Set Cartographic Viewer Map Info

Syntax: **react_set_carto_map_info**($map_info)

Description: Set the Cartographic Viewer Map Info to the specified string. It returns 0 upon successful, 1 otherwise (text attribute will contain the error description).

---

react_load_mlt Loads an MLT file into react

Syntax: result = react_load_mlt($file_mlt, mode)

Description: Loads the specified Map Layers Tree file (.mlt) into the ACT-REACT's Layers Manager. The "mode" argument controls how the mlt has to be added:

mode == 0: replace current tree

mode == 1: append to current tree

mode == 2: prepend to current tree

The returned value will be 0 on success; otherwise an error code is returned, along with a description of the error in the ".text" attribute.

Example:

```
$file_mlt = "my_layers.mlt"
result = react_load_mlt( $file_mlt, 0 )

if ( result ) {

                    // error...
                    result
                    result.text

}
```

react_update_layers *Updates Layers visualization*

Syntax: result = react_update_layers()

Description: Updates the Cartographic Viewer with the visualization of the current layers tree loaded in the Layers Manager.

The returned value will be 0 on success; otherwise an error code is returned, along with a description of the error in the ".text" attribute.

Example:

```
result = react_update_layers()

if ( result ) {

        // error...
        result
        result.text
}
```

react_enable_view *Shows a react panel*

Syntax: result = react_enable_view($panel)

Description: Makes sure that the specified react panel is visible. Currently these are the supported panels:

V_LAYERS (Layers Rendering Tree)

V_3D (3D Viewer)

V_SITES (Target Panel)

V_ANALISYS (Development Environment)

The returned value will be 0 on success; otherwise an error code is returned, along with a description of the error in the ".text" attribute.

Example:

```
result = react_enable_view( "V_LAYERS" )

if ( result ) {

        // error...
        result
        result.text
}
```

react_open_url *Opens an URL in a browser window*

Syntax: s = react_open_url($my_url)

Description: This function opens the specified URL in a web browser window. The functionality is available only in GUI mode, i.e. within ACT-REACT.

Example:

```
$url = "http://www.actgate.com/"
s = react_view_url( $url )
```

react_get_property - Get the value of a ACT-REACT property

Syntax: result = react_get_property($prop_name)

Description: This function returns the value of the specified ACT-REACT property. ACT-REACT has a hierarchical set of objects, and those objects have properties.

In order to access those properties, a “dot” notation is used. For example, "obj1.obj2.obj3.propname" retrieves the "propname" property value of the specified object "obj3" following the ACT-REACT objects hierarchy "obj1.obj2.obj3".

A status value (zero = successful, non-zero = failure) is returned. Its text attribute will contain the command output (upon successful) or a brief description of the error (upon failure).

Example:

```
result=react_get_property("react.mdev.monitoringPanelDocked")
if ( result ) {
        // error...
        result
        result.text
} else {

        $value = result.text
}
```

react_get_properties Get the values for a set of ACT-REACT properties

Syntax: result = react_get_properties($react_object)

Description: This function returns all the property values of the specified object (following the ACT-REACT objects hierarchy) as an XML string. If an empty string is specified (""), it retrieves the entire collection of all properties values of all react objects as an XML string.

A status value (zero = successful, non-zero = failure) is returned. Its text attribute will contain the command output (upon successful) or a brief description of the error (upon failure).

Example:

```
result = react_get_properties( "react.ncda" )

if ( result ) {

        // error...
        result
        result.text

} else {

        $xml = result.text
}
```

The output XML string looks like this:

```
<Object name="react">
        <Object name="ncda">
                <Property name="activeTab">layers</Property>
        </Object>
</Object>
```

react_set_property — *Set the value of a ACT-REACT property*

Syntax: result = react_set_property($prop_name, $prop_value)

Description: This function changes the property value of the specified object (following the ACT-REACT objects hierarchy) to the specified value.

A status value (zero = successful, non-zero = failure) is returned. Its text attribute will contain the command output (upon successful) or a brief description of the error (upon failure).

Example:

```
result=react_set_property("react.mdev.monitoringPanelDocked","1")

if ( result ) {

        // error...
        result
        result.text

} else {

        // successful
}
```

reada Read Array or Image

Syntax: **reada**("fname",$mode[, cntvec])

Description: Reads an array or image from disk. The '$mode' string specifies the format of the data to be read from the disk. If the wrong mode is used with a given file the image will not load properly. The image file formats (or modes) supported are summarize in the following table, followed by a more in-depth description of earch format mode.

If 'fname' contains any environment variables in the form '$(VAR)', those are expanded to their values (see "expand" command).

See Also: Importing Data **, page 41.**

Table 1 Summary of Read-Array/ Writea-Array Format Modes

Format Mode	Brief Description	Bytes/pixel	Read support in MSHELL	Write Support in MSHELL
all	Tries to figure out if the input image is char, gif, float, bmp, jpeg, … or any other format. At this time it does not cover all the possible formats supported by reada(). This format make use of the system variable M_maxdim which determines the maximum image dimension to use.		Yes	N/A
char	MSHELL simple format with a 9 byte header	1 byte/pixel	Yes	Yes
flex	MSHELL reader with powerfull region of interest reader	Multiple …	Yes	N/A
Fits	Flexible Image Transfer format	IEEE float	Yes	Yes, simple format
Tiff	Industry Standard	N/A	Yes	Yes, see also writecolor() function
Gif	Industry Standard	N/A	Yes	Yes
pds	Planetary Data System Support (basic format used in planetary missions)		Yes	Yes (simple format)
float	MSHELL simple format with a 9 byte header	4 bytes /pixel	Yes	Yes
double	MSHELL simple format with a 9 byte header	8 bytes / pixel		
bmp	Industry standard format	N/A	Yes	Yes

jpeg	Industry standard format	N/A	Yes	Yes
asciiflex	MSHELL flexible text loader into numeric array		Yes	N/A
clemen_pds	Clementine Mission Specific	DCT type compression	Yes	N/A

Note that only the charflex and asciiflex formats requires the additional argument ‘cntvec’, please see examples.

Note: for the ‘char’, ‘float’, ‘ascii’, and ‘double’ formats, reada will attempt to load the x.text attribute if it was intitialized in the input file.

The ‘char’ internal format is good to store and retrieve 1 byte data

The **char** format stores images by using 1 byte/pixel prefixed by MSHELL's 9 byte header, i.e. 4 bytes specifying the number of rows, 4 bytes specifying the number of columns, and 1 byte specifying if array elements real or complex. This format can be used both for both the reading and writing of data.

Example: Read **eqohare.chr** image using ‘chr’ format.

```
[ready]:  x = reada("eqohare.chr","char");
[ready]:  view x
```

The ‘flex’format can be used to read almost any image that can be described with the flex-cntvec structure.

The **flex** format provides you significant flexibility when reading various byte/pixel types of data. You can read the whole image or just specified subregions of the image. This is accomplished by using an additional argument, ‘cntvec’. This is a vector with specific data read criteria, and is formated as follows:

```
cntvec =                                              \\
in_sizej::          /* number of rows in input image */     \\
in_sizei::          /* number of col. in input image */     \\
hsize::             /* header size in bytes to skip */      \\
jstart::            /* start row */                   \\
istart::            /* start column */                \\
jend::              /* end row */                     \\
iend::              /* end column */                  \\
jstep::             /* read every 'jstep' row */      \\
istep               /* read every 'istep' column */
```

The syntax for this format is then: **reada**("eqohare.chr","flex_type",cntvec)

The format specifier is “flex_type”; this string can be any of the following:

“char”

"PC16"

"PC32"

"SUN16"

"SUN32"

"PCFLOAT"

"SUNFLOAT"

"PCDOUBLE"

Example: Reading a portion of the **eqohare.chr** image using 'flex'

```
[ready]: eqohare=reada("eqohare.chr","char", \\
                          256::256::9::128::128::255::255::3::1)
[ready]: view eqohare
```

This format is easier to use from the menu with the **File|Image Open** option since a dialog box, illustrated in Figure 4, is provided to facilitate the input of the data read criteria.
[NOT PORTED FROM PROVIEW TO ACT-REACT YET]

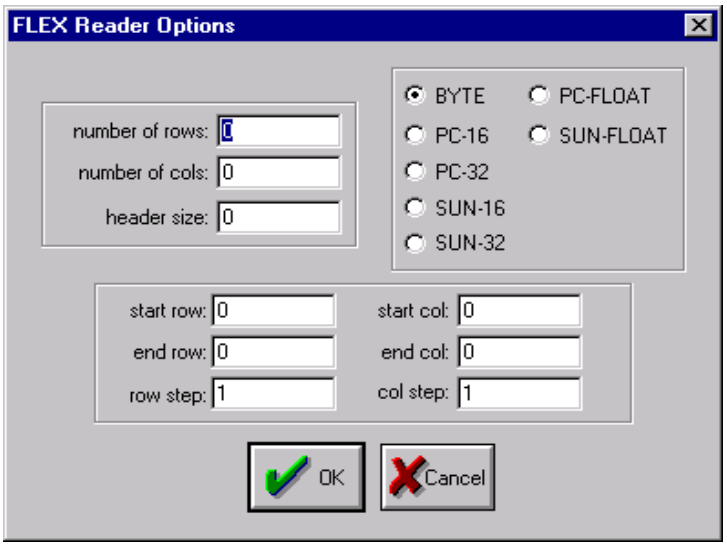


Figure 4 - Charflex dialog box

The 'float' format is a MSHELL internal format for storing single floating point arrays (real or complex)

The **float** format is similar to the char format but the data is stored in floating point using 4 bytes/pixel.

Example: Creating, writing, and then reading in a file in **float** format,

```
[ready]:  y = writea("out.flt", randu(3,3), "float")
[ready]:  x = reada("out.flt","float")
```

The 'double' format is a MSHELL internal format for storing single double precision point arrays (real or complex)

The **double** format is similar to the char format but the data is stored in double precision using 8 bytes/pixel.

Example: Creating, writing, and then reading in a file in **double** format,

```
[ready]:  y = writea("out.dbl", randu(3,3), "double")
[ready]:  x = reada("out.dbl","double")
```

The 'ascii' format is a MSHELL internal format for storing arrays as ASCII values

The **ascii** format stores images in ASCII. A typical ASCII file will look like

```
 3        3        0
-1        0        1
-2        0        2
-1        0        1
```

where the first row is a three element header containing the number of rows, the number of columns, and the real-complex flag (0 = real, 1 = complex). This header is followed by the image data stored lexico-graphically in ASCII. This format can be used for both the reading and writing of data.

Example: Creating, writing, and then reading in a file in **ascii** format,

```
[ready]: y = writea("out.asc", randu(3,3), "ascii")
[ready]: x = reada("out.asc","ascii")
```

asciiflex

The **asciiflex** format permits you to load selected rows and columns from an ascii file. Note that the elements in the ascii file must be comma delimited. A typical ASCII(flex) could look like **test.asc,** below:

```
This is a sample user file
 3,  1,  gain=  2, tint=3
-1,  0,  gain= 22, tint=3
-2,  1,  gain=n/a, tint=3
 0,  2,  gain=  3, tint=0
This is the end of the file
```

where ascii text can be mixed in with the numerical data to be extracted. Note that this read process searches for and accepts the first number it encounters after a delimiter. The syntax is similar to that of char(flex) , using a control vector, 'cntvec" to provide the specific read parameters. The control vector structure, which is differs from that of charflex, is formated as follows:

```
                first_row::/* first row to read */ \\
last_row:: /* last row, if -1 read to last row */ \\
nnchar::           /* non numeric character flag */ \\
hdrsubset::        /* vector of column numbers to read */ \\
cntvec = firstrow::lastrow::nnchar::colvec
cntvec.text = ","
```

The text portion of the control vector contains the delimiter to use for ascii reading. Note that the non-numeric charecter flag value, 'nnchar' is assigned to any array entry encountered in the read process that does not contain an ascii numeric data. The syntax for this format is then:

reada("test.asc","asciiflex",cntvec)

Example: Reading a portion of the **test.asc** file.

```
[ready]: cntvec = 1::-1::-999::0::2 //read rows 1 to end,columns 0 and
2

[ready]: cntvec.text = ","

[ready]: data = reada("test.asc","asciiflex",cntvec)
 [ready]: data
 (10^0) X
row 0 =
  3.00   2.00
row 1 =
 -1.00  22.00
row 2 =
 -2.00 -999.00
row 3 =
  0.00   3.00
row 4 =
-999.00 -999.00
```

Note that in the above example, only the numeric data was extracted from the array entries of column 2; in those cases, rows 3 and 5, that contained non numeric data the designated 'nnchar' value has bee assigned. This flexability in extraction of numeric information from ascii text commented data arrays is a very powerful processing tool.

BMP

The **bmp** format is the windows Bit Map Format (BMP). This format can be used for both the reading and writing of images.

Example: Reading a file in **bmp** format,

```
[ready]: x = reada("mandel.bmp","bmp")
```

PDS

The **PDS** format used is the implementation of the Planetary Data System Format adopted by the Clementine mission.

Within MSHELL there are other functions to support the reading of PDS type data, see internal functions 'pdsfindobj' and 'pdswdstr'.

Example: Reading a file in **PDS** format,

```
[ready]:  // reads image object
[ready]:  x = reada("lua1472h.202","clemen_pds_image_uncorr")
[ready]:  // reads browse image object
[ready]:  x=reada("lua1472h.202","clemen_pds_browse_uncorr")
[ready]:  // reads histogram object
[ready]:  x=reada("lua1472h.202","clemen_pds_hist_uncorr")
```

See Also: **readtext(), readtext_and_status(), readlinef(), readf(), writea(), openf(), closef(), writecolor()**

readf Formatted File Read

Syntax: **readf**(unit,"format",arrayname) or

readf(unit,"format",stringname)

Description: This function is used to perform a formatted read of a scalar or a string from a file unit which has already been opened using the **openf** command. Only one value or string can be read at a time. The format string follows a similar form to the "C" language formatting options, where %s is used for strings, and %f, %g, %e are used for floating point numbers. The first command above is used for reading a value into an already existing array. After executing the **readf** the array will have dimensions of 1x1, i.e. a scalar. The second command above is used for reading a string into an already existing string variable. If the **readf** is successful it will return a value of 0. On end-of-file (eof) a value of -1 is returned.

See Also: **openf, readlinef and M_**.

Example: Assuming that unit 1 has been already open with an **openf** statement, and that the variables 'x' and 'name' are respectively, an array variable and a string variable, then the following MSHELL statements are legal **readf** statements,

```
[ready]: status = readf(1,"%s",$name);
[ready]: status = readf(1,"%f",x);
[ready]: status = readf(1,"%4.2f",x);
[ready]: status = readf(1,"%g",x);
[ready]: status = readf(1,"%e",x); .
```

readlinef Text File Line Read

Syntax: **readlinef**(unit)

Description: This function is used to read a line in a text file. The text file needs to be opened with the **openf** command and the file unit number needs to be provided. Every time the command is called a new line in the file is read. The function returns a status: in case of success the status is 0 and the text field of the status contains the line string with no trailing end-of-line characters ("\n" or "\r\n"). The status returned is -1 when the end of the file is reached. In case of error the text field of the returned value contains a description of the error.

See Also: **openf, readf** and **readtext**

readtext Loads Text File

Syntax: **readtext**($fname) or

readtext($fname, rows, cols, $colSep)

Description: This function is used to load a text file into a memory string. If '$fname' contains any environment variables in the form '$(VAR)', those are expanded to their values (see "expand" command).

In case the text file is a csv file, it is possible to read a subset of rows and columns avoiding to load the whole file into memory. rows and cols are row vectors specifying the list of rows and columns to read. $colSep is the separator for each column. rows and cols must be increasing values. If rows is a NULL array then all ther rows for the specified columns are read. Similarly if cols is a NULL array then all the columns for the specified rows are read.

Example:

```
// load a file into a memory string
$x    =
readtext(M_proviewdir::"/scripts/filtering/spatial_ops/gradient_ops/gra
dient.msf")
print $x            // print the content of the string

// load a URL into a string
$x    = readtext("http://www.actgate.com")
```

readtext_and_status Loads Text File with check

Syntax: **readtext_and_status**($fname)

Description: This function is used to load a text file. It returns a status variable (see example code). If the value is zero the operation was a success. Similar to readtext(), it can be used also to read URLs.

If '$fname' contains any environment variables in the form '$(VAR)', those are expanded to their values (see "expand" command).

Example: ,

```
$file =
M_proviewdir::"/scripts/filtering/spatial_ops/gradient_ops/gradient.msf
"
status = readtext_and_status($file)
if(status==0){
    print status.text   // print the content of the string
}
```

real *Real Part of an Array*

Syntax: **real**(a) or a.**real**

Description: Returns real part for each element in the array 'a'.

Example: The following MSHELL statement will extract the real part of the Fourier Transform of 'a' , and store the result in 'c',

```
c = real( fft2(a) );
[ready]: evaltext $x
```

regionand *Defines a ROI as Common of Two*

Syntax: **regionand**(roi,roi2)

Description: Defines a new region of interest which is the common (overlapping) area of two other regions of interest (roi **and** roi2).

return *Returns From an Include File*

Syntax: **return**

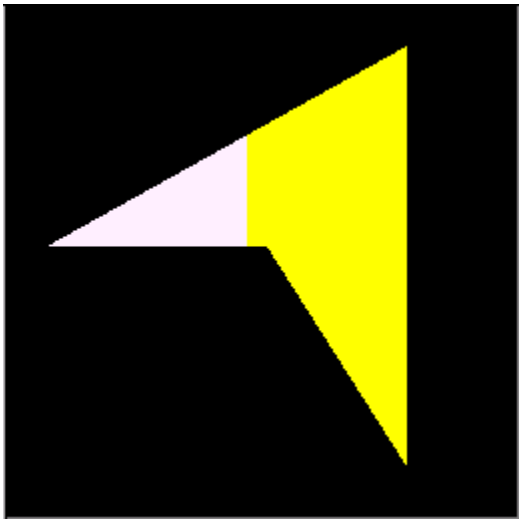
Description: Stops the execution of an include file and returns control to the calling process.

rfill *Fills a subregion*

Syntax: **rfill**(a,b)

Description: Finds the subregion of an image**(**'b'**)** which is all points contained within a created groi from a list of polygonal vertices**(**'a'**)**.

Example:



```
[ready]: groi = complex(20,120)::complex(200,20)::complex(200,230)::complex(130,120)
[ready]: x = zeros(255,255)
[ready]: groi2 = rfill(groi,wdef(0,0,255,255))
[ready]: x(groi2) = 100
[ready]: groi3 = rfill(groi,wdef(0,0,120,120))
[ready]: x(groi3) = 200
[ready]: _
```

rgbTo8Bits *Convert an RGB image into an 8-bits indexed image*

Syntax: img8bits = **rgbTo8Bits**(rgb)

Description: Convert the input RGB image into an 8 bits indexed image with an attached palette.

rindex *Range Index*

Syntax: **rindex**(a,minval,maxval)

Description: This function finds the location of all the elements of an input array which **fall within** a specified range of values, where 'a' is the input array, and 'minval' and 'maxval' are scalar values specifying the selection range. This function returns a (1 x M) complex array, where M is the number of points equal to the specified value and whose array elements contain the coordinates of each point encoded as follows: the real part contains the column index, and the imaginary. part contains row index of the point. If no elements are matched, the value **-1** is returned.

Example: The following illustrates the function using the array 'a'.

```
[ready]: a = randu(2,6) // create random 2x6 matrix
[ready]: a
row 0 =
  0.08   0.59   0.23   0.46   0.93   0.13
row 1 =
  0.79   0.19   0.39   0.33   0.71   0.67
[ready]: rindex(a,.4,.5)
3 + 0i
```

rindexc Range Index Complement

Syntax: **rindexc**(a,minval,maxval)

Description: This function finds the location of all the elements of an input array which fall **outside** within a specified range of values, where 'a' is the input array, and 'minval' and 'maxval' are scalar values specifying the selection range. This function returns a (1 x M) complex array, where M is the number of points equal to the specified value and whose array elements contain the coordinates of each point encoded as follows: the real part contains the column index, and the imaginary. part contains row index of the point. If no elements are matched, the value **-1** is returned.

rmirror Row Mirror

Syntax: **rmirror**(a) or a.**rmirror**

Description: This function yields the mirror image of the input array over its rows, e.g., the last row will become the first row.

See Also: **cmirror**

Example: Creates array 'a' and then does the row reflection,

```
[ready]: a = randu(3,3)
[ready]: a
row 0 =
  0.96   0.42   0.93
row 1 =
  0.17   0.31   0.90
row 2 =
  0.75   0.58   0.65
[ready]: rmirror(a)
row 0 =
  0.75   0.58   0.65
row 1 =
  0.17   0.31   0.90
row 2 =
  0.96   0.42   0.93
```

The following set of **rmshell**_xxxx( )..... functions allow to connect to a remote MSHELL interpreter, send commands, send data, … and get data and results .

---

rmshell_abort Abort the execution of an asynchronous command

Syntax: **rmshell_abort**($handle)

Description: This function works after an rmshell_session_init and can be used to abort the execution of an asynchronous command in the remote MSHELL interpreter. The input argument "$handle" must be a valid string handle to a previously opened remote MSHELL. This function is always successful and will always return 0.

---

rmshell_execute Execute remote command (blocking)

Syntax: **rmshell_execute**($handle, $command)

Description: This function works after an rmshell_session_init and can be used to execute a command in the remote MSHELL interpreter. It takes two arguments: a valid string handle to a previously opened remote MSHELL interpreter and a command string to be executed. This function will block until the execution is finished. If successful, it returns 0 and the text attribute holds the output string generated by the execution of $command. If an error occurs, it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

Example: see rmshell_getarray example.

---

rmshell_execute_async Execute remote command (no block)

Syntax: **rmshell_execute_async**($handle, $command)

Description: This function works after an rmshell_session_init and behaves essentially like the rmshell_execute function but it returns immediately. It takes two arguments: a valid string handle to a previously opened remote MSHELL interpreter and a command string to be executed. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

---

rmshell_ping_server Query state of a ACT-REACT Services instance

Syntax: status = **rmshell_ping_server**($IP_address)

Description: This function queries the state of a running ACT-REACT Services application. It returns 0 if the server replies, 2 if the server doesn't reply, 1 in case of other errors (in which case a description of the error can be found in the status' .text attribute).

---

rmshell_is_session_active Test the state of a SOAP session

Syntax: status = **rmshell_is_session_active**($handle)

Description: This function tests the state of the provided SOAP session. It returns 0 if the session is active; 8 if the session is closed but the ACT-REACT Services is running; 2 if both the session and ACT-REACT Services are down; it will return 1 in case of other errors, i.e. protocol version mismatch. In all these cases, the text attribute can be used to retrieve a brief description of the error.

---

rmshell_wait Wait the number of specified seconds

Syntax: **rmshell_wait**($handle, n_sec)

Description: This function works after an rmshell_session_init and an rmshell_execute_async. It takes two arguments: a valid string handle to a previously opened remote MSHELL interpreter and the number of seconds to wait. If it is –1, this function blocks until the remote server is finished executing the command. Otherwise it waits the number of seconds specified. If the remote server has not yet finished executing the command when the number of seconds elapsed or if an error occurs, it returns a non-zero value, otherwise it returns 0 and the text attribute holds the output string generating by the execution of $command.

---

rmshell_getfile Download a file from the remote MSHELL

Syntax: **rmshell_getfile**($handle, $filelist)

Description: This function works after an rmshell_session_init and can be used to download a file from the remote MSHELL interpreter. It takes tow arguments: a valid string handle to a previously opened remote MSHELL interpreter and a comma-separated string containing the input file name and the output file name. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

Example: see rw_getInventory example.

---

rmshell_getarray — *Get an ARRAY variable from remote*

Syntax: **rmshell_getarray**($handle, $varname)

Description: This function works after an rmshell_session_init and can be used to retrieve the content of an ARRAY variable defined in the remote MSHELL interpreter. It takes tow arguments: a valid string handle to a previously opened remote MSHELL interpreter and the name of the ARRAY variable we want to retrieve the content. If the specified variable does not exist or if an error occurs, it returns a NULL array and the text attribute can be used to retrieve a brief description of the error.

Example: The following example shows most of the remote MSHELL functions being utilized on a simple test case.

```
// opening Remote MSHELL session
$srvr = rmshell_session_init( "212.48.10.150" )
if ($srvr = "") {
                    print "Error opening Remote MSHELL session"
                    return
}

x = hammiw(256, 256)
$s = "I like pineapples"

// whenever 'status' is a non zero-value, its text attribute
// can be used to retrive a brief description of the error
status = rmshell_putarray($srvr, "x")
if (status) {
                    status.text
                    return
}
status = rmshell_putstring($srvr, "$s")

// performing operations remotely
status = rmshell_execute($srvr, "x = x.scale255")
status = rmshell_execute($srvr, "$s = smodify($s, \"pine\", \"\")")

// getting back results
x = rmshell_getarray($srvr, "x")
$s = rmshell_getstring($srvr, "$s")

view x
$s

// closing Remote MSHELL session
status = rmshell_session_close($srvr)
```

rmshell_getstring *Get remote string variable*

Syntax: **rmshell_getstring**($handle, $varname)

Description: This function works after an rmshell_session_init and can be used to retrieve the content of a string variable defined in the remote MSHELL interpreter. It takes tow arguments: a valid string handle to a previously opened remote MSHELL interpreter and the name of the string variable we want to retrieve the content. If the specified variable does not exist or if a an error occurs, it returns an empty string.

Example: see rmshell_getarray example.

rmshell_get_shared_files_list *Get the list of remote shared files*

Syntax: **rmshell_get_shared_files_list**($handle)

Description: This function works after an rmshell_session_init and can be used to retrieve the list of remote shared files the client has access to. See the ACT-REACT-Grid documentation to know how to share a file on the server side.

rmshell_putfile *Upload a file from the remote MSHELL*

Syntax: **rmshell_getfile**($handle, $filelist)

Description: This function works after an rmshell_session_init and can be used to upload a file to the remote MSHELL interpreter. It takes tow arguments: a valid string handle to a previously opened remote MSHELL interpreter and a comma-separated string containing the input file name and the output file name. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

rmshell_putarray *Put an ARRAY variable to remote*

Syntax: **rmshell_putarray**($handle, $varname)

Description: This function works after an rmshell_session_init and can be used to put the content of an ARRAY variable in the remote MSHELL interpreter. It takes tow arguments: a valid string handle to a previously opened remote MSHELL interpreter and the name of the ARRAY variable we want to put the content. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

Example: see rmshell_getarray example.

rmshell_putstring *Put a string variable to remote*

Syntax: **rmshell_putstring**($handle, $varname)

Description: This function works after an rmshell_session_init and can be used to put the content of a string variable in the remote MSHELL interpreter. It takes tow arguments: a valid string handle to a previously opened remote MSHELL interpreter and the name of the string variable we want to put the content. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

rmshell_putvars *Put multiple variables to remote*

Syntax: **rmshell_putvars**($handle, $varslist)

Description: This function works after an rmshell_session_init and can be used to put multiple variables at the same time to the remote MSHELL interpreter. It takes tow arguments: a valid string

handle to a previously opened remote MSHELL interpreter and a comma separated list of variable names to put (both ARRAY varialbes and STRING variables can be specified). If successful, it returns 0, otherwise it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

Note: This function always attempts to complete as many put operations as possible; this means that all put operations that happened before an error condition have been successful.

---

rmshell_session_close Close connection to remote MSHELL

Syntax: **rmshell_session_close**($IP_address)

Description: This function works after an rmshell_session_init and can be used to close a connection to a remote MSHELL interpreter. It takes a valid string handle to a previously opened remote MSHELL interpreter. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

Example: see rmshell_getarray example.

---

rmshell_session_init Connect to a remote MSHELL

Syntax: **rmshell_session_init**($handle)

Description: This function is used to connect to a remote MSHELL interpreter. It takes the IP address (as a string) of the remote machine where the MSHELL interpreter is running. If successful it returns a valid string handle, otherwise it returns en empty string.

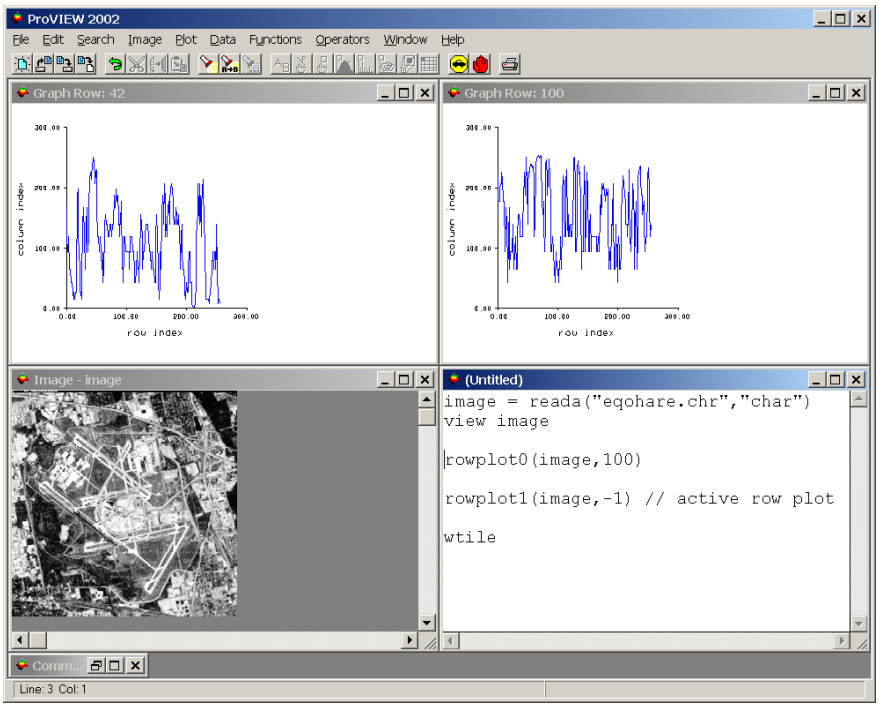
Example: see rmshell_getarray example.

rowplot *Plots a Row from Array [TBD in ACT-REACT]*

Syntax: rowplot[N](array,row#)

Rowplot[N](array,-1) ← for interactive plots

Description: Used to plot a particular row from an array.



rs_availWipeServers Returns available WIPE Server.

Syntax: **$WipeServers = rs_availWipeServers(rs1)**

Description: This function returns a list of names of available WIPE Servers.

Example:

```
[ready]: $WipeServers = rs_availWipeServers(rs1)
[ready]:
```

rs_availDataSets Returns list of available data sets.

Syntax: **rs_AvailDataSets(rs1,"ACTTest")**

Description: This function returns a list of available data sets in a particular WIPE Server.

Example:

```
[ready]: $DataSets = rs_AvailDataSets(rs1,"ACTTest")
[ready]:
```

rs_extractData extract data from the Wipe Server.

Syntax: **rs_extractData(rs1,**

Description: This function is used to extract data from the WIPE Server. The input arguments are the remote server handle, the WIPE Server name, the data item id you wish to extract data from, the layer number, the ROI (subregion), the output image dimensions, the format to save the data in and the filename to save the data into. If the ROI has all the values set to 9999.0, it means we want the whole region the data item occupies. If this function succeds, the return value is 1, otherwise is 0.

Example:

```
[ready]: $RecId = " TEDS_3Dtemp|nwlan_1999071200_tfin"
[ready]: bbox = ones(1,4)*9999.0
[ready]: dim = 41::181
[ready]: layer = 0
[ready]: $format = "netCDF"
[ready]: $fname = "d:\\temp\\temp.nc"
[ready]:ret=rs_extractData(rs1,"ACTTest",$RecId,layer,bbox,dim,$format,
$fname)
```

rs_getMetaData *Extract the metadata request .*

Syntax: **rs_getMetaData(,,,,,,,)**

Description: This function takes as parameters the remote server handle, the name of the WIPE Server, a string containing a list of data set names (comma separated), a string containing the field names to extract from the SQL table, the ROI (ullon::ullat::lrlon::lrlat), start time and end time. The output is a string containing the metadata requested for all the data items in the SQL table that meets the ROI and TOI constraints.

Example:

```
[ready]:$MetaData=rs_getMetaData(rs1,"ACTTest","Sar,TEDS_3Dtemp","DataS
et,ID",-180::90::180::-90,"","")
[ready]:
```

rs_init *loads msh32rs.dll*

Syntax: **rs_init()**

Description: This function loads (dynamically) msh32rs.dll. This DLL contains all the CORBA client code to connect and invoke methods on a remote WIPE Object server . If it succeeds it returns 0, otherwise –1.

Example:

```
[ready]: status = rs_init()
[ready]:
```

rs_connect *connect to a remote WIPE Object*

Syntax: **rs_connect("erie.actgate.com",12000)**

Description: This function is used to connect to a remote WIPE object. It takes two parameters: a string containing the ip address of the WIPE Object host machine, and a port number (this is where WIPE Object Factory Server is set up to listen in). If Successful it returns a handle number, otherwise it returns –1. The handle number is used as a parameter in the other functions.

Example:

```
[ready]: rs1 = rs_connect("erie.actgate.com", 12000)
[ready]:
```

rs_release closes connection with a WIPE Object

Syntax: **rs_release (rs1)**

Description: This function is used to close the connection with a remote WIPE Object.

Example:

```
[ready]: rs_release(rs1)
[ready]:
```

rs_exec Executes command in the remote server

Syntax: **rs_exec(rs1,$cmd)**

Description: This function is used to execute an MSHELL command string in the remote WIPE Object server. It returns 0 if the command executed properly on the remote machine, otherwise it returns the MTOOL error code generated during execution.

Example:

```
[ready]: $cmd = "x = scale255(hammiw(128,128))\n"
[ready]: retval = rs_exec(rs1,$cmd)
```

rs_exec_async Same as rs_exec (does not block)

Syntax: **rs_exec_async(rs1,$cmd)**

Description: This function is similar to rs_exec, excepts that it does not block. The local thread of execution is free to process other commands while the command passed in rs_exec_async executes in the remote server. If succesfull it returns 0.

Example:

```
[ready]: $cmd = "include \"bigloop\"\n"
[ready]: retval = rs_exec_async(rs1,$cmd)
```

rs_getString Retrieves the content of a string variable.

Syntax: **rs_getString(rs1,$varname)**

Description: This function is used to retrieve the contents of a string variable in the remote WIPE Object server. If the string variable does not exists, the function returns a NULL value.

Example:

```
[ready]: $cmd ="$name=\"Hello World!\"\n"
[ready]: retval = rs_exec(rs1,$cmd)
[ready]: $varname = "$name"
[ready]: $temp = rs_getArray(rs1,$varname)
```

rs_getArray Retrieves the content of an Array variable

Syntax: **rs_getArray(rs1,$varname)**

Description: This function is used to retrieve the content of an array variable in the remote WIPE Object server. If the array variable does not exists, the function returns a NULL array.

Example:

```
[ready]: $cmd ="x =scale255(hammiw(128,128))\n"
[ready]:retval = rs_exec(rs1,$cmd)
[ready]: $varname = "x"
[ready]: x = rs_getArray(rs1,$varname)
```

rs_wait Waits the number of specified seconds

Syntax: **rs_wait(rs1, #of seconds)**

Description: This function is used after a call to rs_exec_async. The number of seconds to wait is passed in to the function. If it is –1, this function blocks until the remote server is finished executing the command. Otherwise it waits the number of seconds specified. If the remote server has not finished executing the command when the number of seconds elapsed it returns 1, otherwise it returns 0.

Example:

```
[ready]://wait for 5 seconds; loop until server is finished executing
command
[ready]:while (rs_wait(rs1,5)){
                                        "server is not finished yet… \n"
}
```

rw_getInventory *Retrieve Inventory XML String*

Syntax: **rw_getInventory**($handle, $request)

Description: This function works after an rmshell_session_init and can be used to perform a WIPE server data coverage request by using the remote MSHELL interpreter. It takes two arguments: a valid string handle to a previously opened remote MSHELL interpreter and the coverage XML string. This function will block until the WIPE server response is ready. If successful, it returns 0 and the text attribute holds the output inventory XML string. If an error occurs, it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

Example:

```
// opening a Remote MSHELL session
$srvr = rmshell_session_init( "212.48.10.150" )
if ($srvr = "") {
                    print "Error opening Remote MSHELL session"
                    return
}

// loading data coverage request template from file
$cov = readtext("covTemplate.txt")
// performing request and checking for errors
status = rw_getInventory($srvr, $cov)
if (status) {
                    status.text
                    return
}

// if request has been performed successfully,
// s.text contains the XML inventory string
$inventory = s.text
$inventory

if ( !xmlparse($inventory) ) {
                    print "\nErrors in XML inventory string.\n"
                    return
}

$inventoryImageRelPath = xmltextvalue("CoverageImage")

// the __WROOT__ macro contains the WIPE Server root directory string
// where the output image file is located
$fn = "__WROOT__"::$inventoryImageRelPath::",..\\images\\inventory.jpg"
// retrieving output image file
status = rmshell_getfile($srvr, $fn)

inventoryImage = reada("..\\images\\inventory.jpg", "all")
view inventoryImage

// closing the Remote MSHELL session
status = rmshell_session_close($srvr)
```

rw_getInventoryAsync Retrieve Inventory XML String (does not block)

Syntax: **rw_getInventoryAsync**($handle, $ request)

Description: This function works after an rmshell_session_init and behaves essentially like the rw_getInventoryXML function but it returns immediately. It takes two arguments: a valid string handle to a previously opened remote MSHELL interpreter and the coverage XML string. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

Example: see rw_waitForInventory example.

rw_getMosaic *Retrieve MOSAIC XML String*

Syntax: **rw_getMosaic**($handle, $request)

Description: This function works after an rmshell_session_init and can be used to perform a WIPE server data extraction request by using the remote MSHELL interpreter. It takes two arguments: a valid string handle to a previously opened remote MSHELL interpreter and the MOSAIC request XML string. This function will block until the WIPE server response is ready. If successful, it returns 0 and the text attribute holds the output MOSAIC XML string. If an error occurs, it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

Example:

```
// opening a Remote MSHELL session
$srvr = rmshell_session_init( "212.48.10.150" )
if ($srvr = "") {
                    print "Error opening Remote MSHELL session"
                    return
}

// loading data extraction request template from file
$idb = readtext("idbTemplate.txt")
// performing request and checking for errors
s = rw_getMosaic($h, $idb)
if (status) {
                    status.text
                    return
}

// if request has been performed successfully,
// s.text contains the XML MOSAIC string
$mosaic = s.text
$mosaic

if ( !xmlparse($mosaic) ) {
                    print "\nErrors in XML mosaic string.\n"
                    return
}

$mosaicImageRelPath = xmltextvalue("OutputImage")
$mosaicDataRelPath = xmltextvalue("OutputData")

// the __WROOT__ macro contains the WIPE Server root directory string
// where the output image file is located
$fn = "__WROOT__"::$mosaicImageRelPath::",..\\images\\mosaic.jpg"
// retrieving output image file
status = rmshell_getfile($h, $fn)

mosaicImage = reada("..\\images\\mosaic.jpg", "all")
view mosaicImage
// closing the Remote MSHELL session
status = rmshell_session_close($srvr)
```

rw_getMosaicAsync Retrieve MOSAIC XML String (does not block)

Syntax: **rw_getMosaicAsync**($handle, $ request)

Description: This function works after an rmshell_session_init and behaves essentially like the rw_getMosaicXML function but it returns immediately. It takes two arguments: a valid string handle to a previously opened remote MSHELL interpreter and the MOSAIC request XML string. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

Example: see rw_waitForMosaic example.

---

rw_waitForInventory Wait the number of specified seconds

Syntax: **rw_waitForInventory**($handle, n_sec)

Description: This function works after an rmshell_session_init and an rw_getInventoryXMLAsync. It takes two arguments: a valid string handle to a previously opened remote MSHELL interpreter and the number of seconds to wait. If it is –1, this function blocks until the remote server is finished executing the command. Otherwise it waits the number of seconds specified. If the remote server has not yet finished executing the data coverage request when the number of seconds elapsed or if an error occurs, it returns a non-zero value, otherwise it returns 0 and the text attribute holds the output inventory XML string..

Example:

```
// opening a Remote MSHELL session
$srvr = rmshell_session_init( "212.48.10.150" )
if ($srvr = "") {
                    print "Error opening Remote MSHELL session"
                    return
}

// loading data coverage request template from file
$cov = readtext("covTemplate.txt")
nSecsToWait = 5

// performing request asynchronously and checking for errors
status = rw_getInventoryAsync($srvr, $cov)
if (status) {
                    status.text
                    return
}

// now waiting for the response to be ready
print "waiting "::int2str(nSecsToWait)::" seconds... "
isBusy = rw_waitForInventory($srvr, nSecsToWait)
while ( isBusy ) {
                    print "server is still busy\n"
                    print "waiting "::int2str(nSecsToWait)::"
seconds... "
                    isBusy = rw_waitForInventory($srvr, nSecsToWait)
}
print "server is ready"

// if request has been performed successfully,
// 'isBusy.text' contains the XML inventory string
$inventory = isBusy.text
$inventory

// closing the Remote MSHELL session
status = rmshell_session_close($srvr)
```

rw_waitForMosaic Wait the number of specified seconds

Syntax: **rw_waitForMosaic**($handle, n_sec)

Description: This function works after an rmshell_session_init and an rw_getMosaicXMLAsync. It takes two arguments: a valid string handle to a previously opened remote MSHELL interpreter and the number of seconds to wait. If it is –1, this function blocks until the remote server is finished executing the command. Otherwise it waits the number of seconds specified. If the remote server has not yet finished executing the data extraction request when the number of seconds elapsed or if an error occurs, it returns a non-zero value, otherwise it returns 0 and the text attribute holds the output MOSAIC XML string.

Example:

```
// opening a Remote MSHELL session
$srvr = rmshell_session_init( "212.48.10.150" )
if ($srvr = "") {
                    print "Error opening Remote MSHELL session"
                    return
}

// loading data coverage request template from file
$cov = readtext("idbTemplate.txt")
nSecsToWait = 5

// performing request asynchronously and checking for errors
status = rw_getMosaicXMLAsync($srvr, $idb)
if (status) {
                    status.text
                    return
}

// now waiting for the response to be ready
print "waiting "::int2str(nSecsToWait)::" seconds... "
isBusy = rw_waitForMosaicXML($srvr, nSecsToWait)
while ( isBusy ) {
                    print "server is still busy\n"
                    print "waiting "::int2str(nSecsToWait)::"
seconds... "
                    isBusy = rw_waitForMosaicXML($srvr, nSecsToWait)
}
print "server is ready"

// if request has been performed successfully,
// 'isBusy.text' contains the XML MOSAIC string
$mosaic = isBusy.text
$mosaic

// closing the Remote MSHELL session
status = rmshell_session_close($srvr)
```

SatVIEW computes pointing geometry& spacecraft geometry

Description: This function computes a large list of geometry parameters associated with the user selected space-craft / instrument in relation to a the user selected planetary body, at the time(s) of interest. It uses the **SPICE** (Spacecraft Planet Instrument Camera Events) Kernels that are downloaded with the copy of ACT-REACT. This function leverages in the MSHELL to SPICE bindings discussed in the Appendix.

Syntax: The are two methods of invocation to SatVIEW.

Methods 1: It provides finer control in the command line. Easy to invoke.

satview_process_csv_record($M,$body,$obs,$ins,$time,$int,$outCSVfile)

Method 2: It provides control via a pre-constructed input ASCII file in CSV format, i.e. $inputCSVfile. This mode is good for large batch processing.

satview_process_csv_file($M, $inputCSVfile, $outCSVfile)

where, Input Parameters are:

$M	Input SPICE metakernel file to use. If set to the empty string, i.e. "", it will use the kernels previously loaded in the MSHELL memory, or give an error message if no kernels were loaded.
$body	is the target body under observation. The name must be a valid SPICE body name, e.g. , EARTH, MERCURY, MOON, …
$obs	Name of the observer. The observer can be a knowm planet body, or the name of a spacecraft which is registered within the provided list of input kernels.
$ins	Name of the instrument within the observer system. For example if the observer is the MESSENGER spacecraft a possible instrument is MDIS_NAC.
$TIME	List of times to use, in UTC time, or mission elapsed time (MET) format. Each time provided will generate and output record in the output file, i.e. $outCSVfile.
$int	List of integration times to use for the observer instrument
$inputCSVfile	Under invocation Methods 2, this is the comma space delimited (CSV) input file, where each record contains the required input information to run SatVIEW in this particular mode.

$outCSVfile	This is the output file where the output of SatVIEW is desired.

SatVIEW output file is in comma space value (CSV) delimited format. The following table provides a list of all the output fields produced by SatVIEW. Not all fields will generate values at the same time. For example it the bore-sight of the observing instrument does not intercept the surface the planet surface, then no latitudes&longitude values are reported for the boresight vector.

Field Name (units)	Description (for 1 or more fields)
et (s)	ephemeris time at start of integration time
tint(s)	Integration Time used as sensor observation duration.
SunPosX_J2(Km) SunPosY_J2(Km) SunPosZ_J2(Km)	Derived vector in x,y,z giving sun position in J2000 (J2) reference frame with origin at solar system barycenter.
SCPosX_J2(Km) SCPosY_J2(Km) SCPosZ_J2(Km)	Derived vector in x,y,z giving spacecraft (SC) position in J2000 (J2) reference frame with origin at solar system barycenter.
TargPlanet	This is the target planet or TP.
TP_PosX_J2(Km) TP_PosY_J2(Km) TP_PosZ_J2(Km)	Derived vector in x,y,z giving target body position in J2000 reference frame with origin at solar system barycenter.
TP2SunX_J2(Km) TP2SunY_J2(Km) TP2SunZ_J2(Km)	Target Planet to SUN position in J2000.
TP2SunX_TF(Km) TP2SunY_TF(Km) TP2SunZ_TF(Km)	Target Planet to SUN position in Target Body Fixed (TF) coordinate system.
TP2SC_x_J2(Km) TP2SC_y_J2(Km) TP2SC_z_J2(Km)	Target Planet to Space Craft position vector in J2000.
TP2SC_x_TF(Km) TP2SC_y_TF(Km) TP2SC_z_TF(Km)	Target Planet to Space Craft position vector in Target Body Fixed coordinate system.
TP_VelX_J2(Km/sec) TP_VelY_J2(Km/sec) TP_VelZ_J2(Km/sec)	Target Planet Velocity vector in J2000.
TPtrueAnom(deg)	Derived true anomaly of planet.
SC2TPctrD(Km)	Space-craft to Target Planet center distance.
SubSCLAT SubSCLON	Derived subspacecraft latitude and longitude on planet surface.
NADIR_ALT(Km)	Derived spacecraft altitude above nadir point in meters.
SubSolLAT(deg) SubSolLON(deg)	Derived subsolar latitude and longitude on planet surface.
sc_inst	Name of the instrument aboard the space-craft.

N_BsightV	Number of boresight vectors that will be used in the computation. Normally this matches the number of boresight vectors in the instrument kernel definition
FOV_[i-th](int)	0. This number will match the ith vector in the bore-sight list. Index 0 corresponds to the center of the field of view.
BS_x_J2[i-th](Km) BS_y_J2[i-th](Km) BS_z_J2[i-th](Km)	Derived vector in x,y,z giving instrument [i-th] boresight position in J2000 reference frame with origin at solar system barycenter.
BS_x_TBF[i-th](Km) BS_y_TBF[i-th](Km) BS_z_TBF[i-th](Km)	Derived vector in x,y,z giving instrument [i-th] boresight position in Target Body Fixed reference frame.
BS_pLon[i-th](deg) BS_pLat[i-th](deg)	Derived longitude and latitude of [i-th] boresight intercept point, on planet corresponding to observation.
BS_pEmi[i-th](deg) BS_pInc[i-th](deg) BS_pPha[i-th](deg)	Derived emission, incidence, and phase angle of [i-th] boresight intercept point.
SUN2grnd[i-th](Km)	Derived subsolar distance to [i-th] boresight intercept point on planet surface.
BS_RA[i-th](deg) BS_Dec[i-th](deg) BS_twist[i-th](deg)	Right ascension , declination, and twist angles.
TangHght[i-th](Km) TH_Lon[i-th](deg) TH_Lat[i-th](deg)	
pNearTBFx[i-th](Km) pNearTBFy[i-th](Km) pNearTBFz[i-th](Km)	
sc2BSdist[i-th](Km)	Derived slant range from s/c to [i-th] boresight intercept point in Km (equal to s/c NADIR_ALTITUDE in nadir pointing case).
FOV_[i-th](int)	0. This number will match the ith vector in the bore-sight list.
…	… next block of bore-sight related parameters …
a-smear(Km)	Derived length of VIRS footprint along track over the integration time, accounting for smear across surface.
x-smear(Km)	Derived instantaneous width of VIRS footprint across track at the integration midpoint, accounting for jitter across surface.
a-azimuth(deg)	Derived angle of footprint smear relative to a N-S line. 0 is North, plus/minus 180 is South, sign denotes east (clockwise) or west rotation of azimuth from North..
BLatStart(deg) BLonStart(deg)	
BLatEnd(deg) BLonEnd(deg)	
GLONstart GLATstart GLONend GLATend	

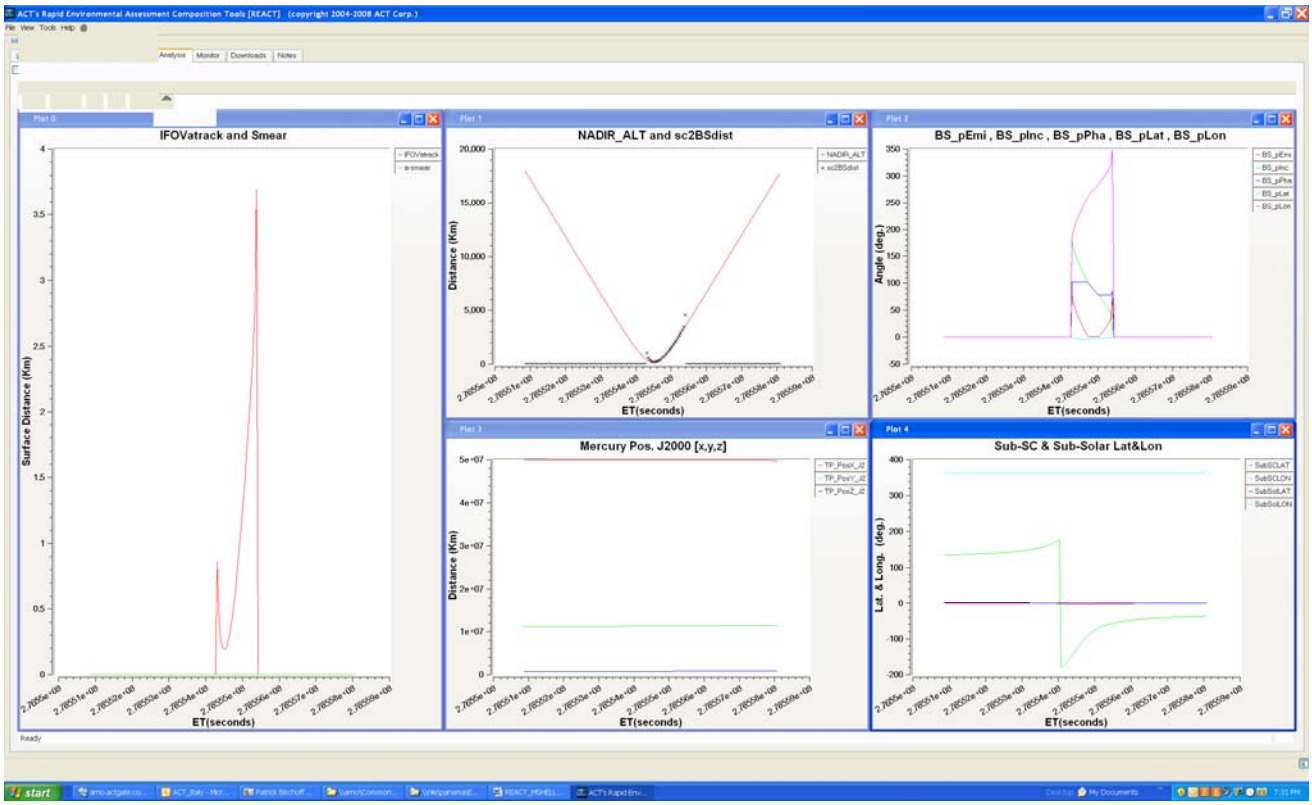


Figure 10 Some output plots from the output of SatVIEW

save *Saves Arrays or Strings to Disk*

Syntax: **save $**savefile array1 array2 array3 …
save $savefile all
save $savefile all_local
save $savefile allstr

Description: Used to save arrays to disk wherby one specifies the desired path and array names to use separated by spaces.

To save all of the ARRAY variables use **save $savefile all**.

To save all the string variables use **save $savefile allstr**.

To save all local ARRAY variable use **save $savefile all_local**

See Also: **load**

scale255 *Scale to 8-bit Range*

Syntax: **scale255**(a) or a.**scale255**

Description: Scale the input array values to fall in the range [0,255]. This function is particularly useful for scaling an array prior to copying it to an 8 bit image frame buffer.

Note that the input to scale255 must be real.

Example: Given that 'a' is a valid array,

```
f = scale255(a);
```

will scale 'a' and copy it into image 'f'.

setcwd *Sets the current working directory*

Syntax: **setcwd(**$string**)**

status = setcwd($string**)**

Description: This is used to set the current working directory from the command line or within a script. The advantage of using this function over the typical M_cwd command is that this captures the state of the change. If status is <0> then the cwd request was successful; if equal to <-1> then it was unsuccessful. This could be because the directory specified does not exist or simply that access permissions have not been met.

Example: The following sets the current working directory to "C:\Temp". Since status = 0, we know that the request was successful.

```
[ready]: status = setcwd("C:\\Temp")
[ready]: status
   0
[ready]:
```

select Selects an Output Look-Up Table

Syntax: **select wolut#**

Description: This is used to select the desired look-up table. The **#** sign will be replaced with the corresponding number for the look-up table desired.
NOTE: THIS FUNCTION IS NOT USED BY ACT-REACT.

Example: The following will select look-up table 2.,

```
[ready] select wolut2
```

SetA_on_Beqindex Assign values to A based on B equality

Syntax: **SetA_on_Beqindex(** A, a_val, B, b_val)

Description: This command allows to assign *a_val* value to *A* elements where corresponding *B* elements are equal to *b_val* value. *A* and *B* can be either real or complex ARRAYs and must be of same dimensions. If *A* is real and *a_val* is complex, then *A* is converted to a complex ARRAY if and only if the equality condition on *B* is met on at least one element of *B*.
This command returns 0 upon successful operation or a non-zero value if an error occurred.

SetA_on_Bnan_index Assign values to A based on B NaN values

Syntax: **SetA_on_Bnan_index(** A, a_val, B)

Description: This command allows to assign *a_val* value to *A* elements where corresponding *B* elements are NaN values. *A* and *B* can be either real or complex ARRAYs and must be of same

dimensions.
This command returns 0 upon successful operation or a non-zero value if an error occurred.

SetA_on_Brindexc Assign values to A based on B range values

Syntax: **SetA_on_Brindexc(** A, a_val, B, b_min::b_max)

Description: This command allows to assign *a_val* value to *A* elements where corresponding *B* elements are smaller than *b_min* or greater than *b_max*. *A* and *B* can be either real or complex ARRAYs and must be of same dimensions.
This command returns 0 upon successful operation or a non-zero value if an error occurred.

setroi Interactively sets an ROI from

Syntax: **setroi(**image**)**

Description: This is used to set a roi from the screen using the mouse for input. After having released the left mouse buton and clicking the right button, the roi will be saved as the rectangular region selected.

Example: The following sets the variable 'roi' equal to the complex array of pixels defining the dragged out contained region within 'image'.

```
[ready] roi = setroi(image)
```

shiftc Cyclic Shift of an Image

Syntax: **shiftc**(a,row,col)

Description: This function is used to shift or translate an input array or image by a specified number of columns and rows. The shift is cyclic, i.e., border pixels will wrap around. Note that the values of 'row" and 'col' must be non-negative.

Example: Included with example of **shiftt**.

shp_from_csv_ll create shapefile from ascii input file

Syntax: **status = shp_from_csv_ll**($inputCSV,$output,$prefix)

Description: This function is used to convert a CSV-formatted list of geometric features (points, open or closed polygons) to an ESRI compliant shapefiles.

The first argument is the input file, the second argument is the output directory and the third argument is a prefix to be put in the output filenames.

The input file contains ASCII text lines, with comma-separated values. The first line is the header and contains the names (again comma-separated) of the data columns. Those names need to be less or equal than 10 characters in length.
Two of the columns must be “lonv” and “latv” containing the longitude and latitude coordinates of the geometric features. If a feature has more than one vertex, the corresponding coordinates have to be separated by double colon. In case of closed polygons, the lon/lat coordinates of the first and the last vertex must coincide.

It is possible to specify the type of each data column appending it to the column name, e.g. *col_name*[FLOAT]. Possible values are [FLOAT], [INT], [STRING]. By default the column data type is initialized to [STRING].

Here is an example of input file:

feat_i,	descr,	lonv,	latv
p1,	point,	140.0,	-82.5
l2,	open,	120.3::130.0	-60.6::-79.8
p2,	closed,	-180::-140::-140::-180::-180,	-82::-82::-87::-87::-82

The function returns a status code, and in case of errors a brief message is returned in the .text attribute.

Status code legend:

0	No errors
1	Input file not found
2	Cannot read input file
7	Column names > 10 characters
8	Exactly one 'lonv' and one 'latv' column must be present
21	'lonv' and 'latv' coordinates do not match in feature
22	Missing 'lonv' / 'latv' columns
9	Line fields number does not match the header
26	Cannot write feature
6	Cannot create feature
3	Shapefile driver not available
4	Creation of output file failed
5	Layers creation failed

shp_query Execute SQL query on a shapefile

Syntax: **shp_query**($filename, $query) **or**
shp_query($filename, $query, spatial_filter)

Description: This function allows to execute an SQL-like query *$query* to fetch a subset of features from an input shapefile *$filename*. Optionally, a spatial filtering *spatial_filter* can be passed to the command to add an additional constraint. The *spatial_filter* variable must be a complex row vector containing the list of vertices of the spatial filtering region (for the time being, only closed polygons are allowed).

shp_records_touching_xypolygon Return features touching an XY region

Syntax: **shp_records_touching_xypolygon**($filename, xyregion)

Description: This function returns the subset of features touching the specified cartographic region *xyregion*. The *xyregion* variable must be a complex row vector containing the list of vertices of the cartographic region (for the time being, only closed polygons are allowed).

shp2contour Shapefile to Contour Image

Syntax: **shp2contour**($filename, bbox, size, recn)

Description: This function generates an image containing a view of the shapefile for a given region and number of records.

‘**$filename**’ is a string containing the name of the shapefile file.

‘**bbox**’ is a 1x4 array containing the bounding box of the region of interest (Xmin, Ymin, Xmax, Ymax), **bbox.text** – optional input containing the ‘proj4’ string that describes the coordinate system of the vector features. Note: This option will be executed as long as there is a valid ‘.prj’ file associated with the shape file. The ‘.prj’ file can contain a WKT (well-known-text) representation of the coordiate system.

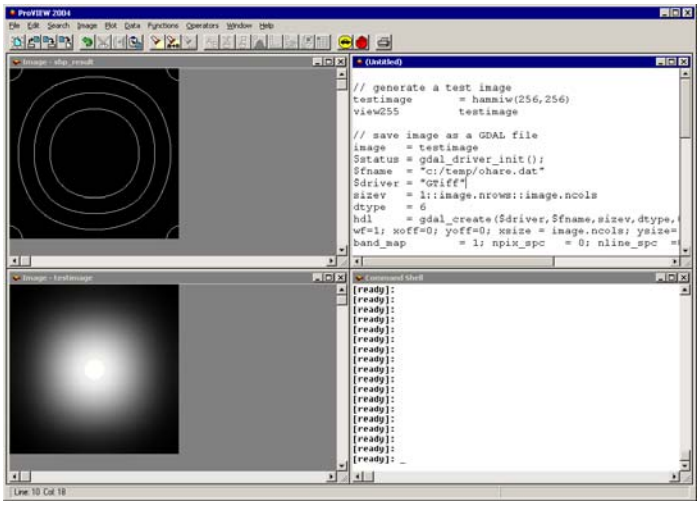
‘**size**’ is a 1x2 array containing the desired image size (rows, columns), and

‘**recn**’ is either a Nx2 array or 0. If ‘recn’ is a Nx2 array, the first column contains the shapefile record id and the second column contains the value to use when drawing the contour for that record; if it is 0, then all the shapefile records are used and the value contained in the system variable M_plotcolor is used for the contour. The generated image can be used as an overlay to another image..

Example: The following example illustrates the function.

```
// generate a test image
testimage           = hammiw(256,256)
view255             testimage

// save image as a GDAL file
image               = testimage
$status             = gdal_driver_init();
$fname              = "c:/temp/ohare.dat"
$driver             = "GTiff"
sizev               = 1::image.nrows::image.ncols
dtype               = 6
hdl                 = gdal_create($driver,$fname,sizev,dtype,0)
wf=1; xoff=0; yoff=0; xsize = image.ncols; ysize= image.nrows;
my_array= image;
band_map            = 1; npix_spc   = 0; nline_spc  =0; nband_spc   =0
status              =gdal_rasterio(hdl,wf,xoff,yoff,xsize,ysize,\\
                    my_array,band_map,npix_spc,nline_spc,nband_spc);

// set parameters to call gdal_contour_generate
band                =1; cinterval=-1; cbase=0
flevels=0.5::0.25::0.1::0.01
flevelcount=flevels.ncols
use_nodata=0
$shapefilename = "c:/temp/shapeout"
$attr="temperature_values"
use3d=0
status              = gdal_contour_generate(hdl,band,cinterval,\\
                    cbase,flevels,use_nodata,$shapefilename,$attr,use3d
)
status=gdal_close(hdl);

/*** View created shapefile as contours ***/
M_format = "00000000000.0000"
$shpfile = $shapefilename::".shp"
ifo                 = getshpinfo($shpfile)
xmin                = ifo(0,4); ymin    = ifo(0,5)
xmax                = ifo(0,6); ymax    = ifo(0,7)
bounds              = xmin::ymin::xmax::ymax
sz                  = image.nrows::image.ncols; recn    = 0
shp_result= shp2contour($shpfile,bounds, sz,recn)
view                shp_result
wtile
```

See Also: gdal_contour_generate, and functions whose name start with ‘shp’, shp2image, shp2fillimage, …



shp2image Shapefile to Image

Syntax: **shp2image**($filename, image, bbox, recn, mode)

Description: This function is **useful when performing polygon fill** of shapefile records of type 5 (polygons). Note: the function shp2fillimage ends up calling this function.

'$filename' is a string containing the name of the shapefile file, 'image' is an array variable used as input to the polygon fill routine (it serves as a background image),

'bbox' is a 1x4 array containing the bounding box of the region of interest (Xmin, Ymin, Xmax, Ymax),

bbox.text – optional input containing the 'proj4' string that describes the coordinate system of the vector features. Note: This option will be executed as long as there is a valid '.prj' file associated with the shape file. The '.prj' file can contain a WKT (well-known-text) representation of the coordiate system.

'recn' can be a Nx2 array, a Nx1 array or 0, and

'mode' is a value that determines the type of output generated:

'0' – fill polygon,
'1' – fill polygon using shapefile record id as the fill value, and
'2' – region add.

The following examples show the different modes in action.

Mode 0 : Polygon Fill

This mode works exactly as shp2fillimage. If 'recn' is a Nx2 array, for each row, the first column contains the shapefile record id and the second column contains the value to use to fill in the corresponding

polygons; if it is a Nx1 array, the column vector contains the shapefile ids to extract from the shapefile; and if it is 0, then all the shapefile records are extracted. The value used to fill in the polygons in the second and third case is determined by the content of the system variable M_plotcolor. The returned image is a combination of the input image and the filled in polygons.

Example: The following example illustrates the function.

```
z = ones(180,360)*100
c = shp2image("d:\\temp\\admin98.shp", z, -180::-90::180::90, 0, 0)
view c
```

Mode 1 – Polygon Fill using Shapefile Record Id

In this mode the record id is used to fill in the polygons. If 'recn' is a Nx1 array, the column vector contains the record ids to extract from the shapefile; if 'recn' is 0 then all the records are extracted. Note that if 'recn' is a Nx2 array the second column is ignored.

Example: The following example illustrates the function.

```
z = ones(256,256)*100
c = shp2image("d:\\temp\\sed.shp", z, -78.015::33.001::-74.992::36.009,
0, 1)
view c
show c
--- c ---
data type is      : real
number of rows    = 256
number of columns = 256
maximum value     = 598
minimum value     = 0
// in this case 598 records were extracted
```

Mode 2 – Polygon Fill with Region Add

This mode is useful when trying to determine overlapping regions. As each polygon is being filled in, the value of the pixels inside the polygon gets increment by the fill value for that record. In this way if you assign the same fill value to every record, areas of overlap will have a greater value than the fill value.

Example: The following example illustrates the function.

```
z = ones(256,256)*100
M_plotcolor = 1
c = shp2image("d:\\temp\\sed.shp", z, -78.015::33.001::-74.992::36.009,
0, 2)
view c
show c
--- c ---
data type is      : real
number of rows    = 256
number of columns = 256
maximum value     = 6
minimum value     = 0
// the maximun value of 6 indicates there were overlapping regions;
// otherwise the maximum value would have been 1
```

shp2fillimage Shapefile Image Fill

Syntax: **shp2fillimage**($filename, image, bbox, recn)

Description: This function is useful when performing polygon fill of shapefile records of type 5 (polygons).

'$filename' is a string containing the name of the shapefile file,

'image' is an array variable used as input to the polygon fill routine (it serves as a background image),

'bbox' is a 1x4 array containing the bounding box of the region of interest (Xmin, Ymin, Xmax, Ymax).

bbox.text – optional input containing the 'proj4' string that describes the coordinate system of the vector features. Note: This option will be executed as long as there is a valid '.prj' file associated with the shape file. The '.prj' file can contain a WKT (well-known-text) representation of the coordiate system.

'recn' can be a Nx2 array, a Nx1 array or 0.

- If 'recn' is a Nx2 array, for each row, the first column contains the shapefile record id and the second column contains the value to use to fill in the corresponding polygon;
- if it is a Nx1 array, the column vector contains the shapefile ids to extract from the shapefile; and
- if it is 0, then all the shapefile records are extracted.

  The value used to fill in the polygons in the second and third case is determined by the content of the system variable M_plotcolor. The returned image is a combination of the input image and the filled in polygons.

Example: The following example illustrates the function.

```
z = ones(180,360)*100
$file = "../../ACT-REACT_data/global/place_find/admin98.shp"
c = shp2fillimage($file, z, -180::-90::180::90, 0)
view c
```

shp2vector Retrieve verticies from a shapefile

Syntax: **shp2vector**($shp_filename, ID)

Description: Given a shapefile name (*.shp), return the verticies for the given shapefile object identifier, ID of the item (1 based).

shpGetInfo provides information on a shapefile

Syntax: **info = shpGetInfo ($filename)**

Description: This function returns an array of information about the shapefile, the description of the output follows
file_cd= 9994,fileSize,version,shapeType,xmin,ymin,xmax,ymax.
If the shape file has an associated '.prj' file, then **info.text** will contain any coordinate system information, e.g. the Well-Known-Text or WKT string.

Example:

```
[ready]: shpGetInfo("c:\\temp\\file.shp")
[ready]:
```

shpwriteroi Copy a subset of a shapefile

Syntax: **shpwriteroi**($shpfile, $dstshpfile,bbox)

Description: Copies the specified bounding box from $shpfile to a newly created shape file, $dstshpfile. Where

bbox = xmin:: ymin :: xmax::ymax

shiftt *Shift an Array or Image*

Syntax: **shiftt**(a,row,col)

Description: This function is used to shift or translate an input array or image by a specified number of columns and rows. The shift is non-cyclic, i.e., border pixels will not wrap-around. Note that the values of 'row" and 'col' must be non-negative.

Example: The example on the next page generates an array and then applies the **shiftc** and **shiftt** functions.

```
[ready]: x = int(randu(3,3)*10) // generate a 3 x 3 array of random
[ready]: x                                  // integers between 1 and
10
 (10^0) X
 row 0 =
  3.00   1.00   2.00
 row 1 =
  9.00   3.00   1.00
 row 2 =
  2.00   5.00   8.00
[ready]: shiftc(x,1,0)             // cyclic shift one row down
 (10^0) X
 row 0 =
  2.00   5.00   8.00
 row 1 =
  3.00   1.00   2.00
 row 2 =
  9.00   3.00   1.00
[ready]: shiftt(x,0,1)             // translation one column right
 (10^0) X
 row 0 =
  0.00   3.00   1.00
 row 1 =
  0.00   9.00   3.00
 row 2 =
  0.00   2.00   5.00
```

show *Display Variables Information*

Syntax: **show** variable [or list of variables]

Description: Display basic parameters of a list of arrays, or of all arrays in memory ("show all"). Also have **show msystem** to show internal system vairables. Note that this command can not be used within an expression.

Example: Generate some variables and then invoke **show**,

```
[ready]: ramp = (0,255,1,256)
[ready]: a = randg(3,100)
[ready]: name = "Carlos"
[ready]: x = 5.00
[ready]: show all
    a            :  3   100 real    defined at level = 0
    x            :  1   1   real    defined at level = 0
    ramp         :  256 256 real    defined at level = 0
    name         :  1    6           string
[ready]: show a
       --- a ---
data type is      : real
number of rows    = 3
number of columns = 100
maximum value     = 2.75168
minimum value     = -2.92469
```

sign *Sign of Array Elements*

Syntax: **sign**(a) or a.**sign**

Description: Compute the sign of each element in the array. For every element in 'a' it returns **+1** if the element is greater than or equal to zero, and **-1** otherwise. This function does not accept complex inputs.

Example: **G**enerate a vector and then apply the **sign** function to the vector.

```
[ready]: a = geo(-2,7)          // generate a row vector
[ready]: sign(a)                // example of sign
row 0 =
  1.00  -1.00   1.00  -1.00   1.00  -1.00   1.00
```

sin *Sine*

Syntax: **sin**(a) or a.**sin**

Description: Compute the sine of each array element.
Note that the input is expected in radians.

sinc *Sinc Function*

Syntax: **sinc**(a) or a.**sinc**

Description: Evaluates the **sinc** function for each element in the input array. The **sinc** function is defined as

.

Note that sinc(0) is evaluated as 1.

sinh *Hyperbolic Sine*

Syntax: **sinh**(a) or a.**sinh**

Description: Computes the hyperbolic sine of each array element.

The hyperbolic sine of x is evaluated as

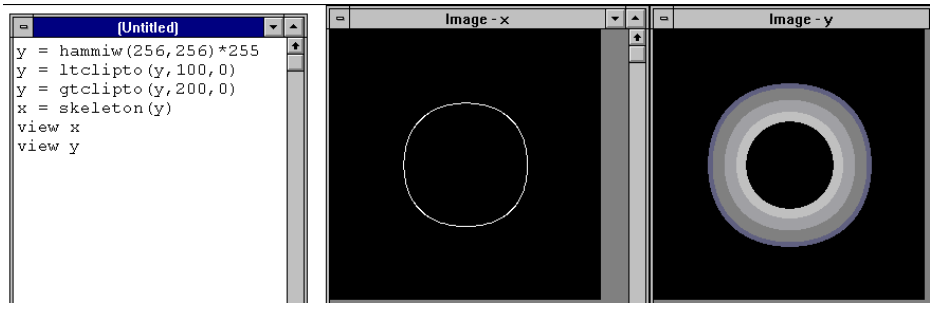
$$\sinh(x) = \frac{e^{x} - e^{-x}}{2}.$$

skeleton *Binary Conversion Filter*

Syntax: **skeleton**(array)

Description: Computes the skeleton on an input image.

Example:



smodify String Replace

Syntax: **smodify(**$string**,**$from**,**$to**)**

Description: This replaces all occurrences of $from with $to in the string $string.

The output of this function can be set to a resultant string also.

Example: This replaces the 'F' in 'Fun' with a 'G' to form "Gun'.

```
[ready]: smodify("Fun","F","G")         // replaces "F" with "G"
Gun
```

sortr Row Wise Sorting

Syntax: **sort**r(a) or a**.sortr**

Description: Returns a sorted version, on a row basis, of the input array. The sorting algorithm utilized is 'Heapsort'. The sorting is performed from small number to large number.

Example: Create an array and then perform a row wise sort of the array.

```
[ready]: a=randu(2,7)           // create random 2x7 matrix
[ready]: a
row 0 =
  0.41   0.72   0.63   0.39   0.62   0.50   0.98
row 1 =
  0.79   0.17   0.01   0.20   0.42   0.10   0.28
[ready]: sortr(a)               // example of sort
row 0 =
  0.39   0.41   0.50   0.62   0.63   0.72   0.98
row 1 =
  0.01   0.10   0.17   0.20   0.28   0.42   0.79
```

spatf Spatial Filter

Syntax: **spatf**(a,n,m,function)

Description: Applies a user selected (or user defined) spatial filter to the input array . The filter is implemented over a moving window through out the whole input array. The dimensions of the window are (N x M). The window must be able to fit within the dimensions of 'a', otherwise an error message will be generated. The final argument, 'function', is the name of a single argument internal MSHELL function which returns a scalar value, e.g., var, mean, max, min, ...

Example: This module provides significant flexibility for performing arbitrary spatial filtering functions. For example, the local mean and variance over the array 'a', using a N x N window, can be computed, respectively, using the following MSHELL calls,

```
spatf(a,N,N,mean)
spatf(a,N,N,var).
```

Likewise, the local maximum over a 9 x 9 window can be computed with

```
spatf(a,9,9,max).
```

sqlite_create — *Creates an empty SQLite database*

Syntax: **sqlite_create**($db_filename)

Description: This function creates an empty SQLite database, stores it in $db_filename (absolute path) and open a connection to the database. Note that $db_filename is created by the sqlite_create() function and must not exist before.

If successful, it returns 0, otherwise it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

sqlite_connect — *Connects to an SQLite database*

Syntax: **sqlite_connect**($database)

Description: Use this command to connect to an existing SQLite database. The string passed is the SQLite database file name. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

Example: see sqlite_getrows example.

sqlite_close — *Closes access to an SQLite database*

Syntax: **sqlite_close**()

Description: Use this command to close connection to the SQLite database. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

Example: see sqlite_getrows example

sqlite_exec — *Sends a query to the SQLite database*

Syntax: **sqlite_exec**($query)

Description: This function executes a query on the opened SQLite database and it is used after an sqlite_connect or an sqlite_create. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

Example: see sqlite_getrows example.

sqlite_getcolnames Returns column names in a result set

Syntax: **sqlite_getcolnames**()

Description: Returns a comma separated list of the column names in a result set. To be called after a SELECT query call to sqlite_exec(). Any expressions in the SELECT statement may be returned as an empty column name, unless the AS operator is used. The column name should match the AS identifier properly.

Example: see sqlite_getrows example.

sqlite_getrows Returns the result set as a string data

Syntax: **sqlite_getrows(**srow,erow**)**

sqlite_getrows (srow,erow,$fname**)**

sqlite_getrows ($colnames,srow,erow**)**

sqlite_getrows ($colnames,srow,erow,$fname**)**

where,

srow – start row number

erow – end row number

$fname – output file name (string)

$colnames – list of requested field names

Description: This function works after a sqlite_connect (or an sqlite_create) and sqlite_exec. After a query this function when invoked will return the result set data as a string. The columns are separated by a | and rows are separated by new lines. This function may be called multiple times on the same result set. There are different ways to extract the results of the query using this function. If an error occurs, it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

Example: The following example shows most of the SQLite functions being utilized on a simple test case.

```
status = sqlite_connect("test.sqlite")
if (status) {
                    status.text
                    return
}
$query = "select * from RobinsonTargets"
status = sqlite_exec($query)
if (status) {
                    status.text
                    return
}
nrec = sqlite_rowcount()

srow = 1
erow = 3
$cols = "site_name,lat1,lon1"
$filename = "sqlite.txt"

s1hdr = sqlite_getrows(0, 0)
if (s1hdr) {
                    s1hdr.text
                    return
}
s1 = sqlite_getrows(srow, erow)
if (s1) {
                    s1.text
                    return
}
print "SQLITE Test 1: extraction of records "::int2str(srow)::" through
"::int2str(erow):: ".\n"
print s1hdr.text::s1.text::"\n"

s2hdr = sqlite_getrows($cols, 0, 0)
if (s2hdr) {
                    s2hdr.text
                    return
}
s2 = sqlite_getrows($cols, srow, erow)
if (s2) {
                    s2.text
                    return
}
print "SQLITE Test 2: extraction of records "::int2str(srow)::" through
"::int2str(erow):: " following provided column names.\n"
print s2hdr.text::s2.text::"\n"

s3hdr = sqlite_getrows(0, 0, $filename)
if (s3hdr) {
                    s3hdr.text
                    return
}

s3 = sqlite_getrows(srow, erow, $filename)
```

```
if (s3) {
                    s3.text
                    return
}
print "SQLITE Test 3: extraction of records "::int2str(srow)::" through
"::int2str(erow):: ". Result is also written into the specified
file.\n"
print s3hdr.text::s3.text::"\n"

s4hdr = sqlite_getrows($cols, 0, 0, $filename)
if (s4hdr) {
                    s4hdr.text
                    return
}
s4 = sqlite_getrows($cols, srow, erow, $filename)
if (s4) {
                    s4.text
                    return
}
print "SQLITE Test 4: extraction of records "::int2str(srow)::" through
"::int2str(erow):: " following provided column names. Result is also
written into the specified file.\n"
print s4hdr.text::s4.text::"\n"

$cols = "lat1,lon1"
erow = 10
s5 = sqlite_getrowsfloat($cols, srow, erow)
print "SQLITE Test 5: extraction of records "::int2str(srow)::" through
"::int2str(erow):: " as an ARRAY variable.\n"
s5

status = sqlite_close()
```

sqlite_getrowsfloat — *Returns the result set as an array*

Syntax: **sqlite_getrows(**srow,erow**)**

sqlite_getrows (srow,erow,$fname**)**

sqlite_getrows ($colnames,srow,erow**)**

sqlite_getrows ($colnames,srow,erow,$fname**)**

where,

srow – start row number

erow – end row number

$fname – output file name (string)

$colnames – list of requested field names

Description: This function works after a sqlite_connect (or an sqlite_create) and sqlite_exec. After a query this function when invoked will return the result set data as an array. The first input argument $column_name is a comma separated list of column names to be retrieved. This function may be called multiple times on the same result set. If an error occurs, it returns a NULL array and the text attribute can be used to retrieve a brief description of the error.

Example: see sqlite_getrows example

---

sqlite_rowcount — *Returns the result set count*

Syntax: **sqlite_rowcount**()

Description: This function works after an sqlite_connect (or an sqlite_create) and sqlite_exec. After a query this function when invoked will return the number of rows in the result set.

Example: see sqlite_getrows example

---

sqlite_transact — *Transacts with an SQLite database*

Syntax: **sqlite_transact**($query)

Description: Use this command to post the passed string as the next query for the previously opened SQLite database. The output of the query, if any, is automatically retrieved. The fields are delimited by the character '|'. If successful, it returns 0 and the text attribute holds the query result string. If an error occurs, it returns a non-zero value and the text attribute can be used to retrieve a brief description of the error.

Example:

```
status              = sqlite_connect("test.sqlite")
$query              = "select site_name, lat1, lon1 "
$query  = $query::"from RobinsonTargets"

$result = sqlite_transact($query)
$result

status              = sqlite_close()
```

sqrt *Square Root*

Syntax: **sqrt**(a) or a.**sqrt**

Description: Computes the square root of each array element in 'a'. If any of the entries in the input array are negative the output of the square root will be complex, i.e. sqrt(-1) = 0+1i, where i implies that the number is imaginary. Taking the square root of a complex array is a valid operation.

stats *Computes Array Basic Statistics*

Syntax: **stats**(a) or a.**stats**

Description: Returns a row vector whose first element is the minimum value in 'a', its second element is the maximum value in 'a', its third element is the mean value of the elements of 'a', and its last element is the standard deviation of the elements of 'a'.

statsx *Computes Statistics with exclusion vlaues*

Syntax: **statsx**(a,exclude)

Description: Returns a row vector whose first element is the minimum value in 'a', its second element is the maximum value in 'a', its third element is the mean value of the elements of 'a', and its last element is the standard deviation of the elements of 'a'. The statistics are computed omitting any values present in the 'exclude' array.

stop_process *terminates execution with message*

Syntax: **stop_process**($error_message)

Description: forces a script to stop its execution (similar to hitting the ESC key) and uses the user provided $error_message string as the message that will initialize the system variable M_errorstring. This function is useful when errors are being trapped by M_errorscript, since the user provided $error_message can be recorded in a database or in a log file. .

STDOUT *Standard out identifier*

Syntax: **writecolor**(**STDOUT**, r, g, b, "TIFF")

Description: Reserved word used to specify the "Standard Out" instead of a file name. (Only works for the console and web versions of MSHELL, not the GUI)

Example: The following MSHELL code will write a JPEG image for a web request coming from an <IMG SRC=…> tag.

```
print "Content-type:  image/jpeg\n\n"
writecolor(STDOUT, red_plane, green_plane, blue_plane, "JPEG")
```

---

str2array Converts Numeric String to ARRAY

Syntax: **str2array**($string, fmode)

Description: This function interprets $string as a string representation of a matrix and converts it into an MSHELL ARRAY variable. 'fmode' is an optional parameter that can be used to specify the format of the input string. If 'fmode' is not specified each row in the input matrix must be linefeed delimited and each element in a row must by comma separated. If 'fmode' is specified the following values are allowed:

fmode = 0, the .text attribute will specify, as a regular expression, the format of the separator string of each element in a row;
fmode = 1, the text attribute will specify, as a regular expression, the numeric format of each element in the input matrix.

If the conversion fails a NULL ARRAY is returned and the text attribute can be used to retrieve a brief description of the error occurred.

See Also: **str2int**, **strlen, strhex2int, float2str**

Example: The following is an example of **str2array** using the standard format.

```
[ready]: $str = "4.56,34.25,67.02\n12.28,34.64,3.23" //define string
variable
[ready]: str2array($str)           // example of str2float

(10^0) X
row 0 =
  4.56  34.25  67.02
row 1 =
 12.28  34.64   3.23
```

Example: The following is an example of **str2array** specifying the format of each element in the input matrix.

```
[ready]:$str = "1234\n5678\n9012"

[ready]:fmode = 1

[ready]:fmode.text = "\\d"  // every single digit will be an element of
the output matrix

[ready]:str2array( $str, fmode )
    1.00,    2.00,    3.00,    4.00
    5.00,    6.00,    7.00,    8.00
    9.00,    0.00,    1.00,    2.00
[ready]:fmode.text = "\\d\\d"   // every pair of digits will be an
element of the output matrix

[ready]:str2array( $str, fmode )
   12.00,   34.00
   56.00,   78.00
   90.00,   12.00
[ready]:
```

str2float Converts Numeric String to Float

Syntax: **str2float**($string, fmode)

Description: This command has been superseded by the newer **str2array**. We strongly advice against using this command in new code. Use the **str2array** instead.

See Also: **str2array**

str2int Converts Numeric String to Integer

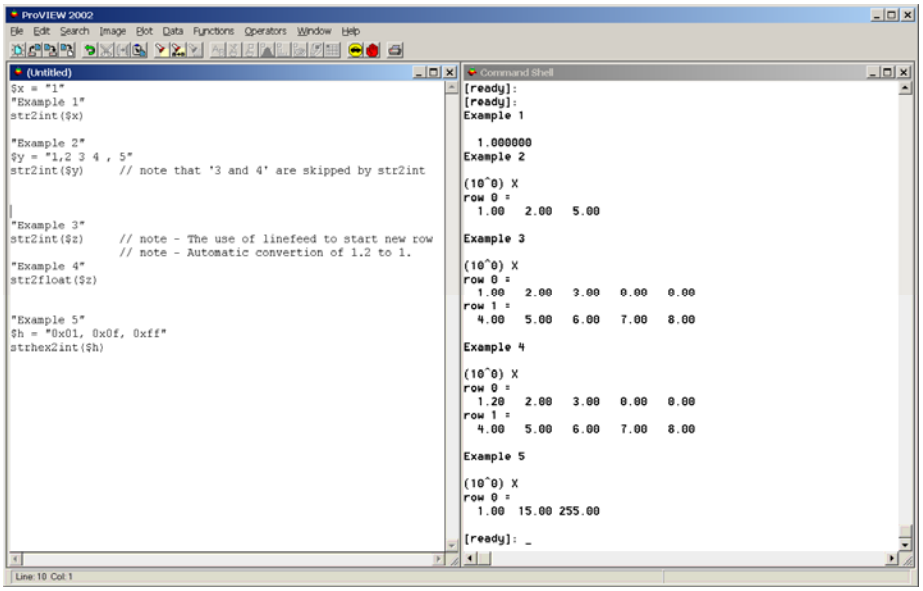
Syntax: **str2int**($string)

Description: Returns an array where numeric values in the string, delimeted by commas or linefeeds, are converted to integer values and then saved in an array variable. Values delimeted by commas are stored in the same array row. The linefeed , '\n' , is used as the row delimeter when copying into the array.

See Also: **str2float**, **strlen, str2float, strhex2int, int2str**

Example: See code below for example usage of str2int(), st2float(), and strhex2int().

```
"Example 1"
str2int($x)

"Example 2"
$y = "1,2 3 4 , 5"
str2int($y)          // note that '3 and 4' are skipped by str2int



"Example 3"
str2int($z)          // note - The use of linefeed to start new row
                         // note - Automatic convertion of 1.2 to 1.
"Example 4"
str2float($z)


"Example 5"
$h = "0x01, 0x0f, 0xff"
strhex2int($h)
```



strContains *check for substring occurance*

Syntax: **strContains(**$a,$pattern**)**

Description: This function return the number of times substring '$pattern' occurs in the input string '$a'.

Example: see strSection( ) example.

strEndsWith check for string termination match

Syntax: **strEndsWith(**$a,$pattern**)**

Description: This function return the value of 1, if it finds the string pattern '$pattern', at the end of the input string '$a'. Otherwise it returns the value 0.

Example: see strSection( ) example.

strFromBase64 Converts from Base64 encoding to plain text

Syntax: **strFromBase64(** $base64str **)**

Description: This function treats the input string as a base 64 encoded string and attempts to convert it to plain text string.

See Also: strToBase64.

strlen Computes the Length of a String

Syntax: **strlen**($string)

Description: Returns a 1 x 1 array with the number of characters in a $string.

See Also: **str2float**, **str2int**

Example: The following generates a string variable and then calculates **str2float**, **str2int**, and **strlen** of the variable.

```
[ready]: $strvalue = "4.356"            // define string variable
[ready]: str2float($strvalue)           // example of str2float
  4.356
[ready]: str2int($strvalue)         // example of str2int
  4
[ready]: strlen($strvalue)              // example of srtlen
  5
```

strhex2int Converts Hex String to Integer

Syntax: **strhex2int**($string)

Description: Returns an array where hex values in the string, delimeted by commas or linefeeds, are converted to integer values and then saved in an array variable. Values delimeted by commas are stored in the same array row. The linefeed , '\n' , is used as the row delimeter when copying into the array.

See Also: **str2float**, **strlen, str2int**

Example: See str2int() example.

strlow2up Converts lowercase to uppercase

Syntax: **strlow2up(**$lowercase**)**

Description: The output is a string whereby all lowercase characters have been changed to uppercase.

strmd5 Compute the MD5 string

Syntax: **strmd5(** $instring **)**

Description: This command computes the MD5 string of the input string *$instring* and returns it as a string.

strStripWhiteSpace Removes whitespaces at the beginning and at the end of a string

Syntax: strStripWhiteSpace($to_be_stripped)

Description: This function removes the whitespaces characters (along with \t, \n and everything that matches (\s) in a regular expression) at the beginning and at the end of the input string.

The result is returned as a string.

strStartsWith check for string start match

Syntax: **strStartWith(**$a,$pattern**)**

Description: This function return the value of 1, if it finds the string pattern '$pattern', at the start of the input string '$a'. Otherwise it returns the value 0.

Example: see strSection( ) example.

strSection extract section of a String

Syntax: **strSection(**$a,$delimiter,start,end**)**

Description: This function mimics Qt's QString::section() function. Given an input string '$a', and a user defined string delimiter '$delimiter', it allows the user to treact the input string as sections, and extract all sections from 'start' to 'end'. This function is quite usefull to break apart commad-space-value (CSV) type of input strings. From left to right section are identified as 0,1,….. From right to left section are identified as -1,-2,….

Example:

```
$a = "my life as a dog"
strStartsWith($a,"my")      // returns 1
strStartsWith($a,"mi")      // returns 0

strEndsWith($a,"as a dog")  // returns 1
strEndsWith($a,"as a cat")  // returns 0

strContains($a,"a")     // returns 2
strContains($a,"lice")      // returns 0

$a = "my life , as a , dog"
strSection($a,",",1,1)
```

strtabSection extract entire columns from CSV string

Syntax: **strtabSection(**$csv_string, col_indexes**)**

Description: This function extracts all rows of specified columns from an input string in comma-separated format (CSV). Column indexes can be specified by the row vector *col_indexes*. This function works after the assumption that the rows are all fixed length and that there are the same number of columns in every row.

See Also: **strTextSubset**

---

strTextSubset *extract entire columns from input string*

Syntax: **strTextSubset**($csv_string, $col_sep, col_indexes)

Description: This function extracts all rows of specified columns from an input string where each column is separated by *$col_sep* token. Column indexes can be specified by the row vector *col_indexes* and they must be increasing values.

See Also: **strtabSection**

---

strToBase64 *Converts to Base64 encoding*

Syntax: **strToBase64(** $str **)**

Description: This function converts the input string to Base 64 encoding.

See Also: **strFromBase64.**

---

strUniqueList *Remove duplicates from a string list*

Syntax: **strUniqueList(** $stringlist **)**

Description: This commands removes duplicate occurrences of strings in an input string list *$stringlist* and returns the result string list.

---

strup2low *Converts uppercase to lowercase*

Syntax: **strup2low(**$uppercase**)**

Description: The output is a string whereby all uppercase characters have been changed to lowercase.

---

sum *Sum All Elements*

Syntax: **sum**(a) or a.**sum**

Description: Sum all the elements in the input array. The output of this operation is a scalar, i.e. a 1 x 1 array.

Example: With example for **sumr**.

sumc *Sum Column Vectors in an Array*

Syntax: **sumc**(a) or a.**sum**c

Description: For each row in the input array, sum the values along the row. The output is a column vector.

Example: With example for **sumr**.

sumcum *Row Wise Cumulative Sum*

Syntax: **sumcum**(a) or a.**sumcm**

Description: For each row in the input array, compute the cumulative sum of values along the row. The output will have the same dimensions as the input.

Example: With example for **sumr.**

sumr *Sum Row Vectors in an Array*

Syntax: **sum**r(a) or a.**sum**r

Description: For each column in the input array, sum the values along the column. The output is a row vector.

Example: The following generates an array and then calculates **sum**, **sumc**, **sumcum**, and **sumr** of that array.

```
[ready]: x = randu(3,3)*10      // generate a 3 x 3 array of random
[ready]: x = nint(x)            // integers in the range of 1 to 10
row 0 =
  2.00   4.00   2.00
row 1 =
  1.00   7.00  10.00
row 2 =
  5.00   5.00   5.00
[ready]: sum(x)                 // example of sum(x)
 41.00
[ready]:
[ready]: sumc(x)                // example of sumc(x)
row 0 =
  8.00
row 1 =
 18.00
row 2 =
 15.00
[ready]:
[ready]: sumcum(x)              // example of sumcum(x)
row 0 =
  2.00   6.00   8.00
row 1 =
  1.00   8.00  18.00
row 2 =
  5.00  10.00  15.00
[ready]: sumr(x)                // example of sumr(x)
row 0 =
  8.00  16.00  17.00 [ready]:
```

svd *Singular Value Decomposition*

Syntax: **svd**(A,U,D,V)

Description: Computes the singular value decomposition of an input matrix. The routine used for this computation is derived from "Numerical Recipes in C", see page 3, "**References and Further Readings**". This routine takes the input matrix, 'A', and returns 'U', 'D', and 'V', which contain the singular value decomposition of 'A'. The following equalities will hold:

U'*U = 1
V'*V = 1
A = U*D*V'

Note that all the input variables must exist before calling this function.

Example: Performs the operation and then checks the result.

```
[ready]: a = randu(2,2) // create a 2 x 2 random array
[ready]: a
row 0 =
  0.23   0.36
row 1 =
  0.16   0.55
[ready]: u=0; d=0; v=0      // initialize u,d,v prior to svd call
[ready]: svd(a,u,d,v)       // call svd function
[ready]: u*d*v'             // test output
row 0 =
  0.23   0.36
row 1 =
  0.16   0.55
```

system Issues Operating System Command

Syntax: **system** string

Description: This function allows you to issue an operating system command. It invokes the operating system command processor to execute a command, batch file, or other program named by the string command. To be located and executed, the program must be in the current directory or in one of the directories listed in the PATH string in the environment. In the case of the string consisting of a an executable command, batch file, or program, you will be returned to the MSHELL prompt upon completion of the executable. If the the string consists of a non-executable statement or is null then returning to MSHELL will require you to type " exit" at the DOS prompt. The COMSPEC environment variable is used to find the command processor program file, so that file need not be in the current directory.

Example: The following operations illustrate the function.

```
[ready]: system "edit c:/autoexec.bat"  // go to DOS, edit the file
[ready]:                                          // when done
returns to the [ready]:                                  // ProVIEW
prompt directly.
[ready]:
[ready]: system                              // opens a DOS window:
c:\>rem                at the DOS prompt you can execute operating
c:\>rem                system commands, batch files, or other DOS
c:\>rem                programs; when done type EXIT
c:\>exit           rem     to return to the ProVIEW prompt
[ready]:                                          // ready to
continue working
[ready]:                                          // in ProVIEW
[ready]:
[ready]: system "dir/s/b > dir.lst"     // creats and stores a listing
[ready]: $list = readtext("dir.lst")        // of files in a directory
```

sys_ Issues Operating System Commands

In this group you will find the following system functions:

```
sys_pwd(…), sys_cd(…), sys_mkdir(…), sys_dir(…),
sys_move(…), sys_ren(…), sys_copy(…), sys_del(…),
sys_deltree(…), sys_dirsize(…), sys_filesize(…),
sys_sendmail(…)
```

Detail syntax and examples are provided below.

sys_pwd Prints the current working directory

Syntax: **sys_pwd**()

Description: This function returns a string containing the absolute path of the current working directory.

Example: Printing the current directory.

```
$dir = sys_pwd()

print "Current directory is "::$dir
```

sys_sendmail Sends mail

Syntax: **sys_sendmail**($srvrIP,$from,$to,$subject,$message)

Description: This function sends an email to email address specified in '$to'. The user must provide the IP address of the mail server in the variable $srvrIP. **This function does not resolve the name of the machine, it must be the IP address.** The function will return a status value. The text component of the status can be checked for any error message. The input parameters are:

$srvrIP - IP address of mail server to use

$from - email address of sender

$to - email address of receiver

$subject - subject string

$message - message string

Example: Sending email

```
$srvrIP                 = "207.87.28.34"
$from                   = "me@actgate.com"
$to                     = "info@actgate.com"
$subject                = "test"
$message                = "just a test of sendmail"

status = sys_sendmail($srvrIP, $from, $to, $subject, $message);
status.text
```

sys_cd — *Changes the current directory*

Syntax: **sys_cd**($newdir)

Description: This function changes the current working directory to $newdir. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute is set with a brief description of the error (see the table below).

Return value	***".text" attribute***	***Meaning***
0	Not set	Success
1	Set	The directory does not exist
2	Set	The argument is not a directory
3	Set	Cannot access the directory

Example: Changing the current directory.

```
$dir = sys_pwd()
print "Current directory (before) "::$dir

s = sys_cd("temp")

if (s) {
   print "An error occurred... "
   s.text
   return
}

$dir = sys_pwd()
print "Current directory (after) "::$dir
```

sys_mkdir — *Creates a directory*

Syntax: **sys_mkdir**($newdir)

Description: This function create the directory $newdir. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute is set with a brief description of the error (see the table below).

Return value	***".text" attribute***	***Meaning***
0	Not set	Success
1	Set	File already exists
2	Set	Directory already exists
3	Set	Object already exists
4	Set	Permission denied

Example: Creating a new directory.

```
s = sys_mkdir("data")

if (s) {
    print "An error occurred ... "
    s.text
    return
}
```

sys_dir — *Directory listing*

Syntax: **sys_dir**($thedir)

Description: This function returns a string containing the list of files and directories located within the directory $thedir; if $thedir is an empty string, the function lists the content of the current directory. Also if $thedir does not exists, is not a directory or is not readable, NULL is returned.

Example: Showing the content of a directory.

```
// listing the current directory
sys_dir("")

// listing the content of "data"
$list = sys_dir("data")

if ($list == "") {
   print "An error occurred... "
   return
}

print $list
```

sys_dirlist — *Controlled directory listing*

Syntax: **sys_dirlist($path,$options)**

Description: This function returns the list of the subdirectories or files of a given directory. The first input argument is a string, containing the directory name. The second input argument is one of the following "d" , "s" or, "p" , where:

- "d" - if used the function will return only the list of subdirectories. Otherwise only the files are listed.
- "s" – if used the function will return the list of files along with their size.
- "p" – if used the function will list the path of the files .

Note: this function uses '|' as the delimiter for each field in a record.

Example:

```
// to print directories, their sizes, and the full path
$out = dirlist("c:\\temp\\*.*", "dsp" )


// to print the directory listing only.  This will not print files
$x = dirlist("F:/crism_pds_archive/trdr/TRDR/*","d")
```

sys_move — *Moves or renames files or directories*

Syntax: **sys_move**($source, $dest)

Description: If the $dest argument is a directory, this function moves the $source argument in it. Otherwise $source is renamed to $dest. Note that $source can be either a file or a directory. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute is set with a brief description of the error (see the table below).

Return value	***".text" attribute***	***Meaning***
0	Not set	Success
1	Set	$source does not exist
2	Set	Permission denied (case: $source --> $dest)
3	Set	Permission denied (case: $source --> $dest/$source)
4	Set	Cannot move to a non directory
5	Set	First argument is neither file nor directory

Example: Moving and renaming files and/or directories.

```
// rename file or directory
s = sys_move("file1.txt", "better_name.txt")
s = sys_move("dir1", "newdir")

// moves "file2.dat" to "data_dir/file2.dat"
s = sys_move("file2.dat", "data_dir")

// moves "old_tree" to "backup/old_tree"
s = sys_move("old_tree", "backup")


// to catch errors:
if (s) {
   print "An error occurred... "
   s.text
   return
}
```

sys_ren — *Renames files or directories*

Syntax: **sys_ren**($oldname, $newname)

Description: This function just renames the $oldname (it can be either a file or a directory) to $newname. Note that this function is provided for convenience, but the same functionality can be achieved with "sys_move". If successful, it returns 0, otherwise it returns a non-zero value and the text attribute is set with a brief description of the error (see the table below).

Return value	***".text" attribute***	***Meaning***
0	Not set	Success
1	Set	First argument does not exist
2	Set	Permission denied
3	Set	Second argument already exists
4	Set	First argument is neither file nor directory

Example: Renaming files and/or directories.

```
// rename files or directories
s = sys_ren("file1.txt", "better_name.txt")
s = sys_ren("dir1", "newdir")


// to catch errors:
if (s) {
   print "An error occurred... "
   s.text
   return
}
```

sys_copy — *Copies files*

Syntax: **sys_copy**($source, $dest)

Description: If the $dest parameter is a directory, this function copies the file $source in it. Otherwise the file $source is copied to a new file named $dest (in the current directory). If successful, it returns 0, otherwise it returns a non-zero value and the text attribute is set with a brief description of the error (see the table below).

Note that $dest is meant to be relative to the current working directory (see the sys_pwd function). Absolute paths should not be used in $dest.

Return value	***".text" attribute***	***Meaning***
0	Not set	Success
1	Set	Source file does not exists
2	Set	First argument is not a file
3	Set	Permission denied (cannot create $dest)
4	Set	Permission denied (cannot create $dest/$source)
5	Set	Last argument exists but it is not a directory

Example: Copying files.

```
// makes a backup copy
s = sys_copy("results.txt", "results_copy.txt")

if (s) {
   print "An error occurred... "
   s.text
   return
}

// copies "file.dat" to "destdir/file.dat"
s = sys_move("file.dat", "destdir")

if (s) {
   print "An error occurred... "
   s.text
   return
}
```

sys_del — *Deletes files or empty directories*

Syntax: **sys_del**($filename)

Description: This function attempts to remove $filename ($filename can be either a file or an empty directory). If successful, it returns 0, otherwise it returns a non-zero value and the text attribute is set with a brief description of the error (see the table below).

Return value	***".text" attribute***	***Meaning***
0	Not set	Success
1	Set	$filename does not exists
2	Set	File access denied
3	Set	Directory not empty
4	Set	Directory access denied
5	Set	Cannot delete the object

Example: Deleting files and (empty) directories.

```
// file
s = sys_del("data.txt")

// directory
s = sys_del("mydir")

if (s) {
   print "An error occurred... "
   s.text
   return
}
```

sys_deltree — *Deletes an entire directory tree*

Syntax: **sys_deltree**($dirname)

Description: This function attempts to recursively remove the directory $dirname along with all its content. If successful, it returns 0, otherwise it returns a non-zero value and the text attribute is set with a brief description of the error (see the table below).

NOTE: If an error (e.g. "Permission Denied") occurs while deleting a file or a sub-directory, the function returns with error 4, but files and directories removed before the error has occurred are permanently deleted.

NOTE[2]: This command has been temporarily disabled as its use can be dangerous.

Return value	***".text" attribute***	***Meaning***
0	Not set	Success
1	Set	$dirname does not exists
2	Set	$dirname is not a directory
3	Set	Cannot remove current or parent directory
4	Set	Cannot delete the entire tree
5	Set	Directory access denied

Example: Deleting a directory tree.

```
s = sys_deltree("old_data")

if (s) {
   print "An error occurred... "
   s.text
   return
}
```

sys_dirsize — *Returns the size of a directory tree*

Syntax: **sys_dirsize**($dirname)

Description: Returns the size of the entire $dirname directory tree. The total size is computed by summing the sizes of all files recursively found within $dirname. If an error occurs, it returns a negative value and the text attribute is set with a brief description of the error (see the table below).

Return value	***".text" attribute***	***Meaning***
Size in bytes	Not set	Success
-1	Set	$dirname does not exists
-2	Set	$dirname is not a directory
-3	Set	Error reading the sub-tree
-4	Set	Directory access denied

Example: Reading the file size of a directory tree.

```
// size of the current directory
size = sys_dirsize(".")

// size of the "data" directory
size = sys_dirsize("data")

if (size < 0) {
   print "An error occurred... "
   size.text
   return
}
```

sys_fileinfo — *Returns detailed information of a file*

Syntax: **sys_fileinfo**($filename)

Description: Returns the size of an existing file in bytes and the date and time created. If the file does not exist it returns **-1**.

Note: This is an alias of the *fileinfo* command.

sys_filesize — *Returns the size of a file*

Syntax: **sys_filesize**($filename)

Description: Returns the size of an existing file in bytes. If an error occurred, it returns a negative value and the text attribute is set with a brief description of the error (see the table below).

Return value	***".text" attribute***	***Meaning***
Size in bytes	Not set	Success
-1	Set	$filename does not exists
-2	Set	$filename is not a file
-3	Set	$filename is not readable

Example: Reading the file size.

```
$file = "fatfile.dat"
size = sys_filesize($file)

if (size < 0) {
   print "An error occurred... "
   size.text
   return
}

print $file::" size is "::int2str(size)
```

sys_cat — *Concatenates input files*

Syntax: **sys_cat**($input_files, $output_file)

Description: Concatenates the input files and writes the result in the specified output file. The input files list ($input_files) is comma separated. If an error occurs, it returns an exit code (greater than zero) with the text attribute containing a brief description of the error (see the table below).

Return value	***".text" attribute***	***Meaning***
0	Not set	Success
1	Set	$input_files: some do not exist
2	Set	$input_files: is not a list of files
7	Set	Cannot open $output_file
6	Set	Cannot read some $input_files
5	Set	$output_file already exists

Example:

```
$inputfiles = "fileA.txt,fileB.txt"
$out = "merged.txt"
status = sys_cat($inputfiles, $out)

if ( status ) {
   print "An error occurred... "
   status.text
   return
}
```

sys_textfilelines — *Returns the number of lines in a text file*

Syntax: **sys_textfilelines**($filename)

Description: Returns the number of lines in at text file. If an error occurred, it returns a negative value.

- T -

---

tan *Tangent*

Syntax: **tan**(a) or a.**tan**

Description: Compute the tangent of each array element. Note that the input is expected in radians.

---

tanh *Hyperbolic Tangent*

Syntax: **tanh**(a) or a.**tanh**

Description: Compute the hyperbolic tangent of each array element.

The hyperbolic tangent of 'a' is evaluated as

$\tanh(a_{j,i}) = \sinh(a_{j,i}) / \cosh(a_{j,i})$ for all i, j;

where j and i are, respectively, row and column idices.

---

textoverlay *Annotates an Image with Text*

Syntax: **textoverlay**(image, $text, "Font", PointSize**::**row#**::** col#**::** color**::** overlay**::** orientation)

Description: This is used to place a text overlay on an image where $text is the string to be displayed, and "Font" is a string specifying the font to use. Row # and column# are the corresponding starting pixels for the text on the image. Color is the color of the text with the folowing possibilities:

0 = black

1 = dark gray

2 = blue

3 = cyan

4 = gray

5 = yellow

6 = magenta

7 = red

8 = green

9 = white

The actual image is not modified with use of this function. It is just

an overlay.

Overlay determines the background of the text where 0 gives a background of white or 1 gives a transparent background. Orientation specifies whether the text is vertical (0) or horizontal (1).

textremove Removes Text annoation

Syntax: **textremove**(image,$text)

Description: Used to remove the desired string ($text) from an image if it was created using the command **textoverlay**. Only works under MSHELL, i.e. the GUI mode.

text2colorimage Converts Text to a color Image

Syntax: **text2colorimage**($sexpr, text_color, bg_color)

Description: Given a single line input string, **text2colorimage** converts the input string into a color image using the specified text color *text_color* and background image *bg_color* (both are in r::g::b format), where 'sexpr' is a string expression Once the text exists in image form it can be manipulated just as any other image.

text2image Converts Text to an Image

Syntax: **text2image**($sexpr)

Description: Given a single line input string, **text2image** converts the input string into a two dimensional array, where 'sexpr' is a string expression Once the text exists in image form it can be manipulated just as any other image.

Example: The ProVIEW screen of Figure 5 illustrates this application.

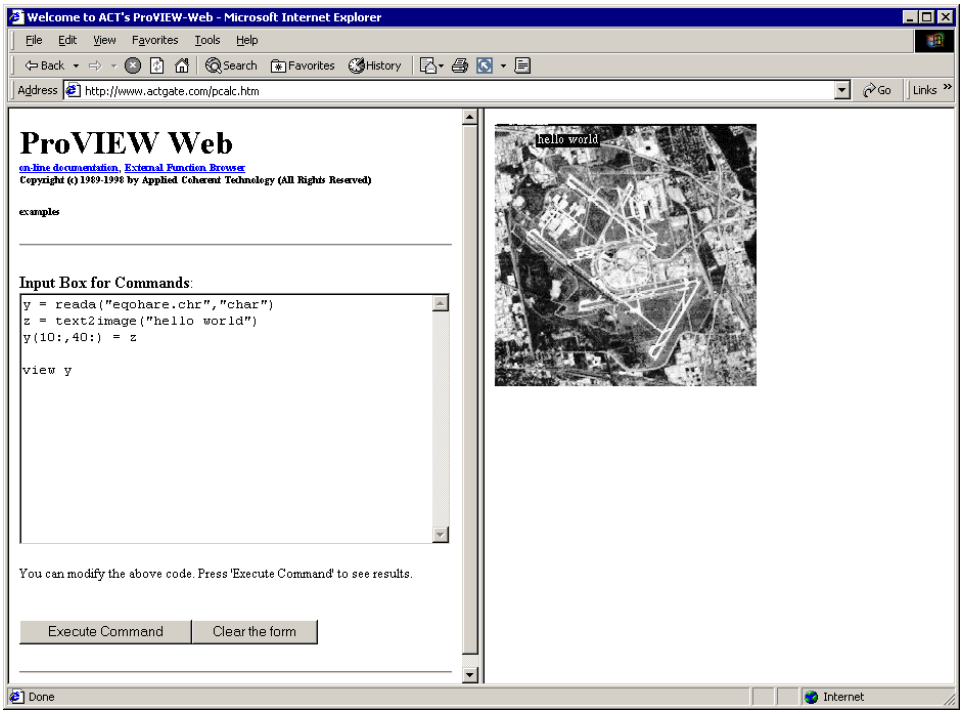


Figure 5

---

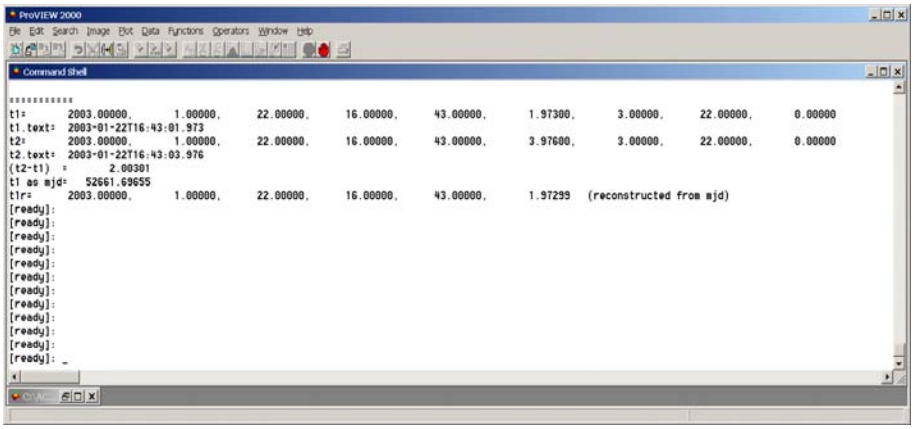
tdiff *computes elapsed time*

Syntax: **tdiff(tstart,tend)**

Description: computes the elapse time, in seconds, between two times points.

Example: The following example illustrates the use of localtimenow(), tdiff(), and dt2mjd(). The function tdiff() makes all its internal computations in double precision. **[See also m2spice_... related functions for support in elapse time computations]**

```
M_format = "000000000.00000"

t1          = localtimenow()
pause(2)
t2          = localtimenow()

print "===========\n"
print "t1=\t"::float2str(t1)::"\nt1.text=\t"::t1.text::"\n"
print "t2=\t"::float2str(t2)::"\nt2.text=\t"::t2.text::"\n"
print "(t2-t1)  ="::float2str(tdiff(t1,t2))::"\n"

t1mjd=dt2mjd(t1)     // compute modified julian date for t1
print "t1 as mjd="::float2str(t1mjd)::"\n"
print "t1r=\t"::float2str(mjd2dt(t1mjd))::"(reconstructed)\n"
```



tprofile_end — *End code block time profiling*

Syntax: **tprofile_end**($descriptor)

Description: Ends time profiling of the block of code specified by $descriptor. Note: in order to enable tprofile functions, M_tprofile_enabled system variable needs to be set to 1.

See Also: **tprofile_start, tprofile_report, tprofile_get_report, tprofile_reset**

tprofile_get_report — *Return time profiling info*

Syntax: **tprofile_get_report**()

tprofile_get_report($descriptor)

Description: Gets time profiling info as CSV string. If $descriptor is passed to the function then returns only profiling info for the specified descriptor. Note: in order to enable tprofile functions, M_tprofile_enabled system variable needs to be set to 1.

See Also: **tprofile_start, tprofile_end, tprofile_report, tprofile_reset**

tprofile_report — *Print time profiling info*

Syntax: **tprofile_report**()

tprofile_report($descriptor)

Description: Prints time profiling info. If $descriptor is passed to the function then prints only profiling info for the specified descriptor. Note: in order to enable tprofile functions, M_tprofile_enabled system variable needs to be set to 1.

See Also: **tprofile_start, tprofile_end, tprofile_get_report, tprofile_reset**

---

tprofile_reset *Reset time profiling info*

Syntax: **tprofile_reset**()

Description: Resets time profiling info. Note: in order to enable tprofile functions, M_tprofile_enabled system variable needs to be set to 1.

See Also: **tprofile_start, tprofile_end, tprofile_get_report, tprofile_report**

---

tprofile_start *Start code block time profiling*

Syntax: **tprofile_start**($descriptor)

Description: Starts block of code time profiling assigning it $descriptor identifier. Note: in order to enable tprofile functions, M_tprofile_enabled system variable needs to be set to 1.

See Also: **tprofile_end, tprofile_report, tprofile_get_report, tprofile_reset**

---

trace *Sum Diagonal Elements*

Syntax: **trace**(a) or a.**trace**

Description: Sums the elements on the diagonal of the input square array.

Example: Generate a square array and calculate **trace.**

```
[ready]: x = randg(3,3)
[ready]: x
row 0 =
    -0.85      0.94      0.16
row 1 =
     1.23     -1.08     -0.46
row 2 =
    -0.88     -0.80      0.41
[ready]: trace(x)
        -1.52219
```

- U -

url_copy_to_file — *Save a remote resource to a file*

Syntax: status = **url_copy_to_file**($url, $local_file)

status = **url_copy_to_file**($url, $local_file, timeout)

Description: This command can be used to retrieve a remote resource and save it to the specified local file path. It returns 0 upon success, 1 otherwise. In case of an error the text attribute of the returned ARRAY contains a brief description of the error.

An optional timeout (in seconds) argument can be specified: if the connection to the remote server takes longer than the specified amount of time, then the function exits.

Example:

```
[ready]: status = url_copy_to_file("http://www.actgate.com/home",
"c:\\temp\\act-homepage.htm")
[ready]: status
    0.00
[ready]:
```

url_copy_to_file_batch_st — *Save multiple remote resources to files*

Syntax: status = **url_copy_to_file_batch_st**($url, $local_file)

Description: This command is the batch version of the **url_copy_to_file** command (single threaded). Inputs are a list of URL resources *$url_resources* and a list of files *$files* where to save the resources.

See also: url_copy_to_file

url_copy_to_file_batch_mt — *Save multiple remote resources to files*

Syntax: status = **url_copy_to_file_batch_mt**($url, $local_file, dl_per_thread)

Description: This command is the batch version of the **url_copy_to_file** command (multi-threaded). Inputs are a list of URL resources *$url_resources*, a list of files *$files* where to save the resources and the number of download per thread *dl_per_thread*.

See also: url_copy_to_file

---

url_copy_to_stdout — *Save a remote resource to standard output*

Syntax: status = **url_copy_to_stdout**($url)

Description: This command acts like the above "url_copy_to_file()" but it puts the remote resource on the Standard Output, instead of a local file

Note: this function is available only in ProVIEW Web.

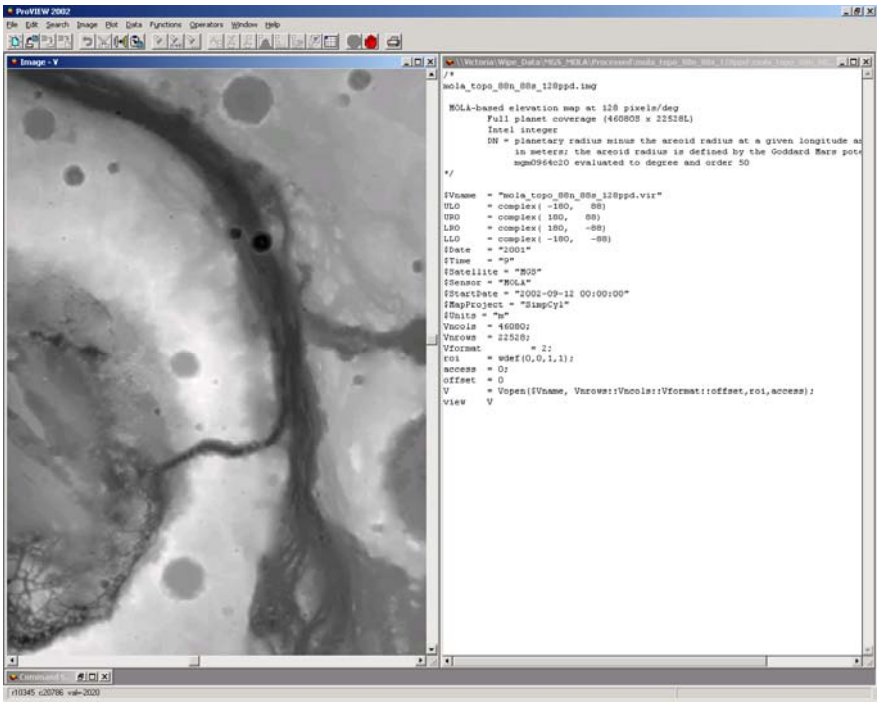
- V -

V *Virtual Variable*

Syntax: **V**

Description: This variable is used to hold the association to the virtual file. All access to any array opened virtually will be performed using this variable.

Example: The following screen shows the usage of the virtual format to read a large mosaic of Mars (ncols = 46080, nrows= 22528). Only a portion of the file is in the display window. As the user moves the scroll bar, it gets resposition to the right viewing location on the map.


ProVIEW 2002
File Edit Search Image Plot Data Functions Operators Window Help
Image - V
/*
mola_topo_88n_88s_128ppd.img
MOLA-based elevation map at 128 pixels/deg
Full planet coverage (46080S x 22528L)
Intel integer
DN = planetary radius minus the areoid radius at a given longitude a
in meters; the areoid radius is defined by the Goddard Mars pot
mgm0964c20 evaluated to degree and order 50
*/
$Vname = "mola_topo_88n_88s_128ppd.vir"
ULO = complex(-180, 88)
URO = complex(180, 88)
LRO = complex(180, -88)
LLO = complex(-180, -88)
$Date = "2001"
$Time = "9"
$Satellite = "MGS"
$Sensor = "MOLA"
$StartDate = "2002-09-12 00:00:00"
$MapProject = "SimpCyl"
$Units = "m"
Vncols = 46080;
Vnrows = 22528;
Vformat = 2;
roi = wdef(0,0,1,1);
access = 0;
offset = 0
V = Vopen($Vname, Vnrows::Vncols::Vformat::offset,roi,access);
view V

See Also: Vopen, Vnew, Vclose,

Vclose *Closes Virtual Variable Link*

Syntax: **Vclose**(V)

Description: This function is used to close the link between the virtual variable 'V' and the disk file it was previously attached to by **Vopen**.

See Also: **Vnew**,and **Vopen.**

Vnew *Makes Disk Space for Virtual Image*

Syntax: **Vnew**($fname, nrows,ncols,bytes_per_pixel)

Description: This function is used to allocate disk space in a disk file, where: '$fname' is the string variable holding the file name to use, 'nrows' is the number of rows in $fname, 'ncols' is the number of columns in $fname, and 'bytes_per_Pixel' is the number of bytes per pixel in '$fname'. Returns status of **0** for **good**.

See Also: **Vclose**, **Vopen**.

Vopen *Makes Virtual Variable Link to File*

Syntax: V = Vopen($fname,M::N::format::offset,roi,access);

Description: This function establishes a link between the Virtual Variable 'V' and a disk file '$fname', where: M is the number of rows in '$fname', 'N' is the number of columns in '$fname', byte 'format' is determined by the list below, 'offset' is the header size in bytes, and 'roi' is a valid rectangular region of interest within '$fname'. Also the access parameter has been added to allow just read (access = 0) or read and write (access = 1).

MSHELL Virtual variable formats:

Format 1:	Byte
Format 2:	PC16
Format 3:	Sun16
Format 4:	PC float
Format 5:	Sun float
Format 6:	PC32
Format 7:	Sun32
Format 8:	PC16 unsigned
Format 9:	Sun16 unsigned

See Also: **Vclose, Vnew.**

Note that 'V' is a special variable in MSHELL, a virtual variable. With this variable you can manipulate an image file which can be as large as the whole disk space available in the system. If the user has a huge image in a file or is going to be working with an image that can not be easily hold in memory, then he or she can still manipulate pieces of the large image using MSHELL's virtual variable.

Once a link is established between a file in disk and the virtual variable 'V', then the user can access rectangular regions of interest in the disk file for read or write operations (the user must always provide a rectangular region of interest when writing or reading from the 'V'). The following example illustrates the use of a virtual variable. It corresponds to the script file **flyby.msh** located in the MSHELL **msh** distribution directory.

```
        M_cwd = "/proview/images/clemen/moonbrus"
roi = wdef(0,0,1,1)
V = Vopen("allmoon.chr",5760::11521::1::0,roi,0);
flyby = 0
view flyby
i=0
while(i<35){
        meter("flyover virtual image",i/35*100)
        angle = i/35*6.28
        roi = wdef(2336+128*cos(angle), 6926+128*sin(angle), 256,256)
        flyby = V(roi)
        i = i+1
}
meter("",-1)
```

var *Variance*

Syntax: **var**(a) or a.**var**

Description: Given an input array, 'a', **var**(a) computes the variance of the elements in 'a'. The variance is computed using the following expression,

$$\mathrm{var}(a) = \frac{1}{J \cdot I} \sum_{i=0}^{I-1} \sum_{j=0}^{J-1} (a_{j,i} - \bar{a})^2 \quad \text{where,}$$

$$\bar{a} = \frac{1}{J \cdot I} \sum_{i=0}^{I-1} \sum_{j=0}^{J-1} (a_{j,i}) \quad \text{is the sample mean of 'a' ,for all j, i;}$$

where j and i are, respectively, row and column indices.

varname *Returns the Variable Name*

Syntax: **x.varname**

Description: returns the name of the variable as a string, i.e. 'x'.
For example $mystring = x.varname

See Also: M_inputfocus

---

vartype Returns the Variable Type

Syntax: **vartype**(variable)

Description: This is used to pass the "type" of the specified variable to the screen so that the user knows what "type" a particular variable is. "Type" is a number which can be one of the following possibilities:

0 = means that the variable does not exist

1 = signifies an integer or array

2 = signifies a string

---

vec2image Vector Format to Image Format

Syntax: **vec2image()**

Description: converts from vector format into an image representation in memory. (UNDER DEV.)

---

vect_intercept_index Find intercept indexes on a curve

Syntax: **vect_intercept_index(curves, values, options)**

Description: This command attempts to find the intercept indexes between the given curves *curves* and the specified values *values*, as a row vector. It returns the intercept indexes or -1 where no intercept was found. *options* is a place holder for future implementations and must be now set to 0. This command works in 2 modes, depending whether the input *curves* is a single curve or several curves.
SINGLE CURVE. If *curves* is a single curve it can be specified as a row or a column vector. In this case *values* represents the list of values to find intercept indexes. For each value in *values* it returns the interpolated index of the current value in the given curve, or -1 if the value is not within the boundary of

the curve.
MULTIPLE CURVES. The variable *curves* can be a matrix representing a set of curves, either rowwise or columnwise. In this case *values* is treated as the list of values to find intercept in each single curve (e.g first value will find intercept in the first curve, second value will find intercept in the second curve, and so on). It returns the list of intercept indexes, where intercept index *i* is the intercept index of $values_i$ in the $curve_i$, or -1 if no intercept was found (i.e. $value_i$ was out of $curve_i$ boundary).

Example:

```
> a = (1, 10, 1);   // linear ramp from 1 to 10 with step 1
> a
 1.00, 2.00, 3.00, 4.00, 5.00, 6.00, 7.00, 8.00, 9.00,10.00
> b = 2.5::7::20;   // values to find intercept in 'a'
> vect_intercept_index( a, b, 0 )       // a is a single curve
 1.50, 6.00,-1.00
> a_matrix = a#2*a#3*a      // multiple curves
> vect_intercept_index( a_matrix, b, 0 )        // a is a single curve
 1.50, 2.50, 5.67
```

viewout *Closes array viewing window*

Syntax: **viewout** image

Description: Closes array viewing window associated with the image variable. (GUI only).

view *Enables Screen Display of an Image*

Syntax: **view** myimage

Description: From the command line or from a script file, use this command to enable the display of any image variable, i.e. 'myimage', that already exits in memory. Note: after version 3 of MSHELL, you can assign indivudal palettes to the image before it is displayed by setting the 'x.LUT' attribute.

Example:

```
x = reada("eqohare.chr","char");    // open and image
view x;
y = x;                  // assign x to y
y.LUT = (255,0,1,3) // assign an inverse palette to y
view y;
```

view255 Enables Screen Display of a Scaled Image

Syntax: **view255** myimage

view255 myimage,exclude_val_vec

Description: From the command line or from a script file, use this command to enable the display of any image variable, i.e. 'myimage', that already exits in memory. The display image will be set to use autoscaling. In the second usage usage, the user can control the automatic scaling such that a range of values provided by 'exclude_val_vec' are not used in the computation. This is particularly usefull to avoid non-image-data values.

Example:

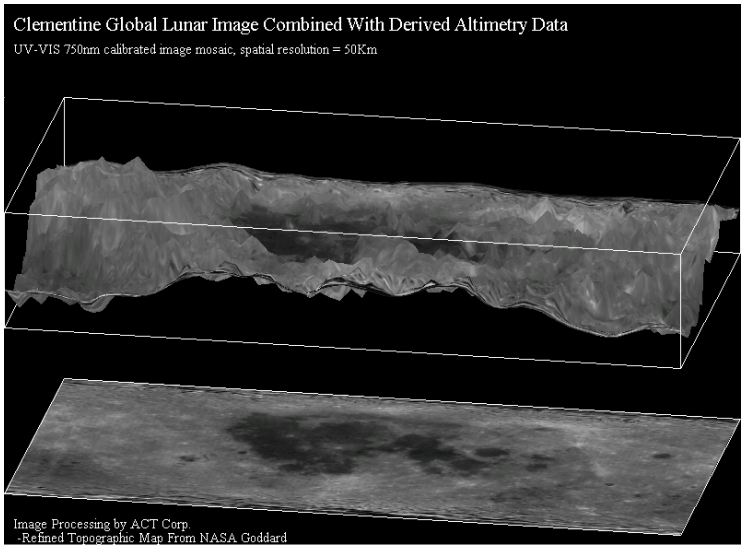
```
Image=hammiw(256,256);
view255 Image;      // autoscales the image
Image2 = Image;     // make a copy
Image2(0,0)=1/0     // introduce an outliner
Image2(5,5)=100     // introduce another outliner
view255 Image2,1/0::100 // will display a nice image
```

view4d *project planar image into an xyz grid*

Syntax: **view4d**(image,xy,z,rot::tilt::nout::ns)
Note: this function is being replaced by '**image2surface'**

Description: Given an input image defined over a rectangular grid, this command will reproject the image intensities to a user requested xyz grid. The command is called view4d because it uses amplitude and xyz information (4dimensions). It also applies a rotation of 'rot', and a tilt of 'tilt', generating and output image of 'nout' rows/columns. The sampling of the input xy or z place is controlled via 'ns=1,…,8', where ns=1 is most accurate and ns=8 is the least accurate.

Example 1: The following example uses view4d to take the albedo image of the moon and and a height image of the moon and generate a draped version of the albedo image over the Digital Terrain elevation image. In the script file below, the 'uvvis750.flt' file corresponds to the lower image; in the top image this file has been altitude enhanced with the topography image 'luntopo/4'.


Clementine Global Lunar Image Combined With Derived Altimetry Data
UV-VIS 750nm calibrated image mosaic, spatial resolution = 50Km
Image Processing by ACT Corp.
-Refined Topographic Map From NASA Goddard

```
M_cwd = M_proviewdir::"/IMAGES"
luntopo = reada("luntopo.flt","float")

uvvis750 = reada("uvvis750.chr","char")
uvvis750 = decimate(uvvis750,2,2)

luntopo = shiftc(luntopo,0,180)

luntopo              = scale255(luntopo)
view luntopo
MOON = view4d(uvvis750,0,luntopo/4,-10::70::800::5)
MOON.m_viewflag=0

MOON = zeropad(MOON,MOON.nrows+100,MOON.ncols)
MOON = shiftc(MOON,100,0)

MOON.m_viewx0=0
MOON.m_viewy0=0
MOON.m_viewwidth=MOON.ncols+50
MOON.m_viewheight=MOON.nrows+50
MOON.m_viewflag=1   // make image visible
view MOON
// *******ADD TEXT TO OUTPUT IMAGE
row=10; col=10
$text = "Clementine Global Lunar Image Combined With Derived Altimetry
Data"
textoverlay(MOON,$text,"Times New Roman",24::col::row::9::1::1)

row=40; col=10
$text = "UV-VIS 750nm calibrated image mosaic, spatial resolution =
50Km "
textoverlay(MOON,$text,"Times New Roman",18::col::row::9::1::1)

row = MOON.nrows-30; col=10
$text = "Image Processing by ACT Corp."
textoverlay(MOON,$text,"Times New Roman",18::col::row::9::1::1)

row = MOON.nrows-15; col=10
$text = " -Refined Topographic Map From NASA Goddard"
textoverlay(MOON,$text,"Times New Roman",18::col::row::9::1::1)
```

- W -

wcascade *Cascades all Screen Windows*

Syntax: **wcascade**

Description: Cascades all the windows presently opened in the MSHELL environment.

wclose *Closes all Screen Windows*

Syntax: **wclose**

Description: Closes all the windows presently opened in the MSHELL environment.

wcolut[#] *Color Look up Table*

Syntax: **wcolut**[#]

Description: Used to list and define all three rows (red, green, blue) of a color look up table. Use the **select** command or the **m_viewlut** intrinsic with wolut# to choose one of the palettes for viewing.

0=gray

1=inverse gray

2=pseudocolor

3=inverse pseudocolor

4=user defined

Note: starting in MSHELL version 3, the scheme for tracking lookup tables associated with array variables was changed. See array attribute **'x.LUT'** *for details. That is, a color palette can be assigned to each individual array.*

wdef *Define a Region of Interest*

Syntax: **wdef**(ul_row,ul_col,nrows,ncols)

Description: This function is used to define a region of interest or window, where: 'ul_row' and 'ul_col' are the upper left pixel coordinates of the region of interest; 'nrows' and 'ncols' are, respectively, the number of rows and columns contained in the region of interest.

Example: The following command defines **roi**1 to be a 16 x 16 rectangular region of interest with upper left corner at row = 8 and col = 6.

```
[ready]: roi1 = wdef(8,6,16,16)
[ready]: froi = f(roi1) // extracts subimage
```

which *Return the full path to an MSHELL script or function*

Syntax: **which** "script-name"

Description: This function can be used to print the full file path to the specifed script name (.msh file) or function name (.msf file).

```
[ready]: which "minit"
c:\act\ACT-REACT\scripts\minit.msh
```

while *While Loop*

Syntax: **while** *(condition)* {

statements

counter

}

Description: This is a type of loop which runs until the condition stated is nolonger met.

wmove *Move a Region of Interest*

Syntax: **wmove**(roi,row,col)

Description: Given a valid rectangular region of interest, 'roi', originally defined using **wdef** this function will generate a new region of interest which is a translated version of the input ROI, where 'row' and 'col' are the row and column coordinates of the upper left of the translated region of interest, and 'roi' is the input region of interest.

wolut[#] *Windows Output Look Up Table*

Syntax: **wolut**[#]

Description: This is used to apply one of the output look-up-tables to a particular image. The wolut[#] system variables are used with the **select** command or **m_viewlut** intrinsic to choose a lookup table to use. For example: select wcolut0 will select the grayscale lookup table. To read or modify the lookup tables RGB values, use the wcolut[#] system variables.

0=gray

1=inverse gray

2=pseudocolor

3=inverse pseudocolor

4=user-defined

*Note: starting in MSHELL version 3, the scheme for tracking lookup tables associated with array variables was changed. See array attribute '***x.LUT'** *for details. That is, a color palette can be assigned to each individual array.*

---

writea Write Array to Disk

Syntax: **writea**("fname",a,"mode")

Description: Write an array, 'a', to file 'fname' on the disk in the indicated 'mode', using any of the supported formats. For a discussion on the modes see description provided in the reada() function.

Note: for the 'char', 'float', 'ascii', and 'double' formats, this function will save x.text attribute if it was intitialized in the array to write to disk.

See Also: reada(), Vopen(), fits_...(), nc_...(), pds_...(), writef()

---

writecolor Writes a Color Image

Syntax: **writecolor**("path/filename.ext", r, g ,b, "image type")

Description: NOTE: THIS FUNCTION IS REPLACED BY writeRGB().
Used to write a color image to disk using the three red(r), green(g), blue(b) image color arrays. The image type string is simply the type of image to be written (*tiff*,jpeg,png*)*.

---

writeRGBA Writes an RGB or RGBA Color Image

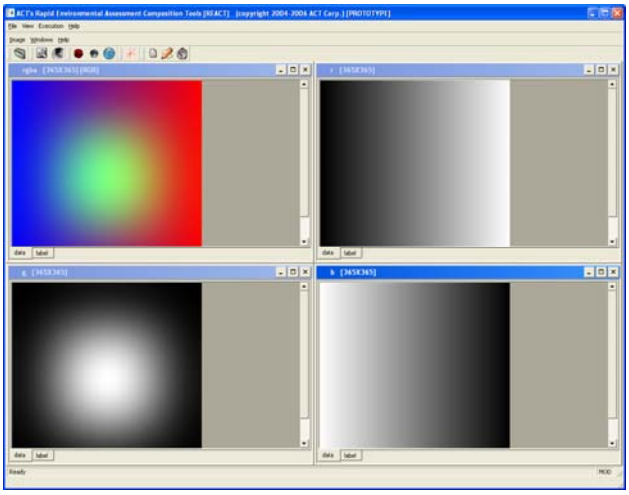
Syntax: **writeRGB**($file, r, g ,b, $type)
writeRGBA($file, r, g ,b, a, $type)

Description: Used to write a color image to disk using the three red(r), green(g), blue(b) image color arrays. The image type string, $type, is simply the type of image to be written, e.g.

BMP, GIF, JPEG, PBM, PGM, PNG, PPM, XBM, XPM

Example:

```
N = 365
r = scale255((0,N-1,1,N))
g = scale255(hammiw(N,N))
b = (255-r)

q = r#g#b
alternateRGB(q);
view q
a = r
writeRGB(M_proviewdir::"/temp/color.png",r,g,b,"PNG");
writeRGBA(M_proviewdir::"/temp/color_rgba.png",r,g,b,a,"PNG");
rgba = reada(M_proviewdir::"/temp/color_rgba.png","all");
view rgba
```



writetext_enc Encrypt a string and write to file

Syntax: **writetext_enc**($file, $string)

Description: This command encrypts the input string *$string* and writes it to the specified file *$file*. This command can be used to encrypt an MSHELL script or function script. In this case the encrypted script must have the extension **.meh** for MSHELL scripts and **.mef** for MSHELL function script in order to be called by MSHELL as regular scripts.

Example:

```
// converting a regular script to an encrypted script
$script = readtext( "myscript.msh" )
writetext_enc( "myscript.meh", $script )
// calling the script as usual
include "myscript.meh"
```

writef *Formatted File Write*

Syntax: **writef**(unit,"format",arrayname) or

writef(unit,"format",stringname)

Description: This function is used to perform a formatted write to a file unit which has already being open using the **openf** command. Note that only one value or string can be written at a time**.** The first command above is used for doing a formatted write of an already existing 1 x 1 array into a file. The second command above is used for doing a formatted string write into an already open file. The format string follows a similar form to the 'C' language formatting options, where %s is used for strings, and %f, %g, %e are used for floating point numbers.

Example: Given that unit 1 has been already open with an **openf** statement, and that 'x' is an array variable and 'name' is a string variable, then the following MSHELL statements are legal **writef** statements,

```
status=writef(1,"Hello my name is %s \n",name);
status=writef(1,"The temperature is %f degrees",x);
status=writef(1,"The value is \n %4.2f",x);
status=writef(1,"%g",x);
status=writef(1,"%e",x); .
```

wsize *Size of a Region of Interest*

Syntax: **wsize**(roi) or roi.**wsize**

Description: Given a valid rectangular region of interest, this function will return the dimensions of the rectangular window defining the ROI.

wtile *Tiles all Screen Windows*

Syntax: **wtile**

Description: Tiles all the windows presently opened in the MSHELL environment.

- X -

---

xcorr *Cross Correlation*

Syntax: **xcorr**(a,b)

Description: Perform the cross-correlation between two input arrays. There are no specific restrictions on the two input arrays: they can be either real or complex and one or two dimensional. If 'a' has dimensions (N x M), and 'b' has dimensions (P x Q) the resulting ARRAY will have dimensions (N+P-1, M+Q-1). The implementation used in 'xcorr' is computationally efficient for small arrays. For large array sizes, an **FFT** implementation should be considered.

See Also: **xcorrt**

Example: Example with **xcorrt.**

---

xcorrfft *Cross-correlation of two FFT's*

Syntax: **xcorrfft**(FFT1, FFT2)

Description: This is used to find the cross-corrleation between two computed FFT's of certain previous arrays. This command is especially advantageous where a cross-correlation of two large arrays would be processor comsumptive; therefore, an FFT (being much smaller) would be much faster to compare.

---

xcorrt *Truncated Cross Correlation*

Syntax: **xcorrt**(a,b)

Description: This function is similar to **xcorr** except that it only evaluates the cross correlation in the range of the second array. This function, **xcorr**t, truncates the cross-correlation results by only evaluating the cross-correlation over the range of 'b'. Note that 'a' is assumed to have odd dimensions.

Example: The following illustrates the use of **xcorr** and **xcorrt**,

```
[ready]: x = 2::4::2
[ready]: y = (0,2,1)
[ready]: z = xcorr(x,y)     // example of xcorr
row 0 =
  0.00   2.00   8.00  10.00   4.00
[ready]: zp = xcorrt(x,y)       // example of xcorrt
[ready]: zp
row 0 =
8.00  10.00
```

xline Extract Pixel Values along Line Segment

Syntax: **xline**(a,row1,col1,row2,col2)

Description: This function extracts the pixel values along a line segment in an array. The coordinates (row1, col1) and (row2, col2) are, respectively, the start and end points of the line segment. Note that **xline**(a,row1,col1,row2,col2) is equivalent to the following MSHELL instruction based on the **bresen** and **complex** □unctions: **bresen**(**complex**(col1::col2,row1::row2)).

See Also: **bresen.**

Example: For the given an array, the following will calculate both the xline and the a(besen(complex(0::3, 0::3))) transformations of the array.

```
A = hammiw(4,4)                 // generate a 4 x 4 array
a
 (10^0) X
row 0 =
    0.0064     0.0432     0.0800     0.0432
row 1 =
    0.0432     0.2916     0.5400     0.2916
row 2 =
    0.0800     0.5400     1.0000     0.5400
row 3 =
    0.0432     0.2916     0.5400     0.2916
xline(a,0, 0, 3 ,3)             // example of xline
 (10^0) X
row 0 =
    0.0064       0.2916     1.0000     0.2916
0.0432
a(bresen(complex(0::3,0::3)))
    0.0064       0.2916     1.0000     0.2916
```

xlinec Extracts Coordinates of Line

Syntax: **xlinec**(image)

Description: Used to list the coordinates along a linear region of interest. Once the command has been issued in the command window, then one is prompted to click the endpoints of the desired linear region within the image of interest.

xlinev Extracts Vertices of Line

Syntax: **xlinev**(image)

Description: Used to list the vertices or end point of a linear region of interest. Once the command has been issued in the command window, then one is prompted to click the endpoints of the desired linear region within the image of interest.

xlut Look-Up-Table Transformation

Syntax: **xlut**(a,lut)

Description: Performs a permanent look up table transformation on the given input array 'a' using a user supplied look-up-table, 'lut'.

Example: Suppose it is desired to transform an array region of interest in image f using an inverse ramp mapping. This can be done using,

```
f = reada("eqohare.chr","char")
roi = wdef(0,0,20,30)
f(roi) = xlut(  f(roi) , (255,0,1) ) ;
```

xmlattrvalues Extracts the attribute values

Syntax: **xmlattrvalues("keyword","value")**

Description: this function is used to extract the attribute values associated with tags that share the same name. The input arguments are the tag name and the attribute name.

Example:

```
[ready]: //tag name: "keyword", attribute name:"value"
[ready]: $attr = xmlattrvalues("keyword","value")
```

xmlparse parse an XML string.

Syntax: **xmlparse($meta)**

Description: This function is used to parse an XML string. When excuted it loads dynamically (behind the scene) msh32xml.dll. The input argument is an XML string. It returns 1 if the parsing was successful l, otherwise it returns 0.

Example:

```
[ready]: status = xmlparse($meta) //$meta is an XML string
[ready]:
```

xmltextvalue Extracts the text value of a

Syntax: **xmltextvalue("metadata.idinfo.spdom.bounding.northbc")**

Description: This function is used to extract the text values of a particular node in the DOM tree. The input argument is a string where the node names in the hierarchy are separated by '.'.

Example:

```
[ready]: $nbc = xmltextvalue("metadata.idinfo.spdom.bounding.northbc")
[ready]:
```

xmltextvalues Extracts the text values

Syntax: **xmltextvalues("northbc")**

Description: This function is used to extract the text values associated with tags that share the same name. The input argument is a string containing the tag name.

Example:

```
[ready]: $txtvals = xmltextvalues("northbc")
[ready]:
```

xpolyc Extracts Coordinates of a Polygon

Syntax: **xpolyc**(image)

Description: Used to list the coordinates along a polygonal region of interest. Once the command has been issued in the command window, then one is prompted to click the vertices of the desired polygonal region within the image of interest.

---

xpolyv *Extracts Vertices of a Polygon*

Syntax: **xpolyv**(image)

Description: Used to list the vertices of a polygonal region of interest. Once the command has been issued in the command window, then one is prompted to click the vertices of the desired polygonal region within the image of interest.

- Z -

zeropad *Expand an Image with Zeroes*

Syntax: **zeropad**(a,n,m)

Description: Add zeros to the input array 'a', where n is the number of rows and m is the number of columns.

Example: Takes a 2 x 2 array and pads it to a 3 x 5 array.

```
[ready]: x = (1::2)#(3::4)
[ready]: x
row 0 =
  1.00   2.00
row 1 =
4.00
[ready]: y = zeropad(x,3,5)
[ready]: y
row 0 =
  1.00   2.00   0.00   0.00   0.00
row 1 =
  3.00   4.00   0.00   0.00   0.00
row 2 =
  0.00   0.00   0.00   0.00   0.00
```

zeros *Initialize Array to all Zeros*

Syntax: **zeros**(n,m)

Description: Create an array in memory with all the elements set to 0.

Example: The following MSHELL statement will create the 512 x 512 array 'c' in memory with all entries set to 0.

```
C = zeros(512,512);
```

zinterp Zero Order Interpolation

Syntax: **zinterp**(f,x)

zinterp (f, x, offset)

Description: This is used to perform zero-order interpolation on an array "f", by expanding the data to a range specified by the "x" array which will list the abscissa and ordinate indices for each new desired element. It is possible to specify an "offset" to apply to x. It can be a complex for abscissa and ordinate offset or a real for applying the same offset to abscissa and ordinate.

Appendix C: Remote Access

Introduction

A number of functions allow MSHELL to perform remote communication via CORBA. The following table contains the present set of function calls that are being tested and that have been added to the MSHELL language.

The following internal functions (defined in Appendix B) support remote invocations of MSHELL (using CORBA):

rs_init
rs_connect
rs_release
rs_exec
rs_exec_async
rs_wait
rs_getString
rs_getArray
rs_availWipeServers
rs_availDataSets
rs_getMetaData
rs_extractData

See detail discussion of the above functions in Appendix B.

Appendix D: Cartographic Library

PROJ CopyRight Notice

The MSHELL function Geo2Cart is based on the PROJ cartographic program/library developed by USGS. Copyright to PROJ and usage description follows.

CopyRight Notice associated to the Cartographic DLL

All source, data files and other contents of the PROJ.4 package are
available under the following terms. Note that the PROJ 4.3 and earlier
was "public domain" as is common with US government work, but apparently
this is not a well defined legal term in many countries. I am placing
everything under the following MIT style license because I believe it is
effectively the same as public domain, allowing anyone to use the code as
they wish, including making proprietary derivatives.
Though I have put my own name as copyright holder, I don't mean to imply
I did the work. Essentially all work was done by Gerald Evenden.

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FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER
DEALINGS IN THE SOFTWARE.

NAME

proj - forward cartographic projection filter
invproj - inverse cartographic projection filter

SYNOPSIS

proj [**-bceEfiIlmorsStTvVwW** [*args*]] [**+args**] file[s]
invproj [**-bceEfiIlmorsStTwW** [*args*]] [**+args**] file[s]

DESCRIPTION

Proj and *invproj* perform respective forward and inverse transformation of cartographic data to or from cartesian data with a wide range of selectable projection functions.
The following control parameters can appear in any order:

-b

Special option for binary coordinate data input and output through standard input and standard output. Data is assumed to be in system type *double* floating point words. This option is to be used when **proj** is a *son* process and allows bypassing formatting operations.

-i

Selects binary input only (see **-b option).**

-I

alternate method to specify inverse projection. Redundant when used with **invproj.**

-o

Selects binary output only (see **-b option).**

-t*a*

A specifies a character employed as the first character to denote a control line to be passed through without processing. This option applicable to ascii input only. (# is the default value).

-e *string*

String is an arbitrary string to be output if an error is detected during data transformations. The default value is: *\t*. Note that if the **-b, -i** or **-o** options are employed, an error is returned as HUGE_VAL value for both return values.

-E

causes the input coordinates to be copied to the output line prior to printing the converted values.

-l*[p|P|=|e|u]***id**

List projection identifiers with **-l, -lp** or **-lP (expanded)** that can be selected with **+proj. -l=***id* gives expanded description of projection *id.* List ellipsoid identifiers with **-le,** that can be selected with **+ellps** or **-lu** list of cartesian to meter conversion factors that can be selected with **+units.**

-r

This options reverses the order of the expected input from longitude-latitude or x-y to latitude-longitude or y-x.

-s

This options reverses the order of the output from x-y or longitude-latitude to y-x or latitude-longitude.

-S

Causes estimation of *meridinal* and *parallel* scale factors, *area* scale factor and *angular distortion,* and *maximum* and *minimum* scale factors to be listed between <> for each input point. For conformal projections meridinal and parallel scales factors will be equal and angular distortion zero. Equal area projections will have an area factor of 1.

-m *mult*

The cartesian data may be scaled by the *mult* parameter. When processing data in a forward projection mode the cartesian output values are multiplied by *mult* otherwise the input cartesian values are divided by *mult* before inverse projection. If the first two characters of *mult* are 1/ or 1: then the reciprocal value of *mult* is employed.

-f *format*

Format is a *printf* format string to control the form of the output values. For inverse projections, the output will be in degrees when this option is employed. If a format is specified for inverse projection the output data will be in decimal degrees. The default format is "%.2f" for forward projection and DMS for inverse.

-[w|W]*n*

N is the number of significant fractional digits to employ for seconds output (when the option is not specified, **-w3** is assumed). When **-W** is employed the fields will be constant width and with leading zeroes.

-v

causes a listing of cartographic control parameters tested for and used by the program to be printed prior to input data. Should not be used with the **-T** option.

-V

This option causes an expanded annotated listing of the characteristics of the projected point. **-v is implied with this option.**

-T *ulow,uhi,vlow,vhi,res[,umax,vmax]*

This option creates a set of bivariate Chebyshev polynomial coefficients that approximate the selected cartographic projection on *stdout.* The values *low* and *hi* denote the range of the input where the *u* or *v* prefixes apply to respective longitude-x or latitude-y depending upon whether a forward or inverse projection is selected. *Res* is an integer number specifying the power of 10 precision of the approximation. For example, a *res* of -3 specifies an approximation with an accuracy better than .001. *Umax,* and *vmax* specify maximum degree of the polynomials (default: 15). See also: fproj**(1).**

The **+args** run-line arguments are associated with cartographic parameters and usage varies with projection and for a complete description see *Cartographic Projection Procedures for the UNIX Environment---A User's Manual)* and supplementary documentation for Release 4.

Additional projection control parameters may be contained in two auxilliary control files: the first is optionally referenced with the **+init=***file:id* and the second is always processed after the name of the projection has been established from either the run-line or the contents of **+init** file. The environment parameter **PROJ_LIB** establishes the default directory for a file reference without an absolute path.

One or more *files* (processed in left to right order) specify the source of data to be transformed. A - will specify the location of processing standard input. If no files are specified, the input is assumed to be from *stdin.* For ASCII input data the two data values must be in the first two white space separated fields and when both input and output are ASCII all trailing portions of the input line are appended to the output line.
Input geographic data (longitude and latitude) must be in DMS format and input cartesian data must be in units consistent with the ellipsoid major axis or sphere radius units. Output geographic coordinates will be in DMS (if the **-w** switch is not employed) and precise to 0.001" with trailing, zero-valued minute-second fields deleted.

EXAMPLE Usage

The following script

```
proj +proj=utm +lon_0=112w -r <<EOF
 45d15'33.1"    111.5W

 45d15.551666667N       -111d30

 +45.25919444444        111d30'000w

 EOF
```

will perform UTM forward projection with a standard UTM central meridian nearest longitude 112°W. The geographic values of this example are equivalent and meant as examples of various forms of DMS input. The x-y output data will appear as three lines of:

```
460769.27      5011648.45
```

SEE ALSO

Cartographic Projection Procedures for the UNIX Environment---A User's Manual, (Evenden, 1990, Open-file report 90-284).
Map Projections Used by the U. S. Geological Survey (Snyder, 1984, USGS Bulletin 1532).
Map Projections---A Working Manual (Synder, 1988, USGS Prof. Paper 1395).
An Album of Map Projections (Snyder & Voxland, 1989, USGS Prof. Paper 1453).

HOME PAGE FOR THIS CODE

http://www.remotesensing.org/proj

Appendix E: MSHELL-GDAL Bindings

GDAL CopyRight Notice

The **Geographic Data Abstraction Library** (GDAL) is a translator library for raster geospatial data formats that is released under an **X/MIT** style **Open Source** license. As a library, it presents a **single abstract data model** to the calling application for all supported formats. The related **OGR** library (which lives within the GDAL source tree) provides a similar capability for simple features vector data. More information can be found at:
http://www.remotesensing.org/gdal/index.html

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ACT-REACT/MSHELL-GDAL Interface

ACT-REACT&MSHELLhas incorporated support to the **Geographic Data Abstraction Library** (**GDAL**). ACT-REACT&MSHELLmostly leverages on GDAL to facilitate the access to many geographical raster-data-formats, see Table 2, and to read and convert widely used spatial reference systems (**SRS**) representations in the open-source community (proj4 and WKT formats).

A number of functions in the MSHELL scripts tree subdirectory use of the GDAL low level functions. In particular the cartographic map projection script functions. i.e.

map_image.msf - cartographic map of a single image file
map_images.msf - cartographic mosaic of a list of image files
map_image_to_file.msf - creates cartographic mosaic on disk (good for HUGE mosaics)

which are located in the …/scripts/Satellite_Image_Mapping/Mosaics directory.

These script function are by themselves great examples, within MSHELL, on the use of the low level GDAL functions. The above script functions can handle input files that use ground control points (GCP) for geo-referencing, or that are already in cartographic projection space.

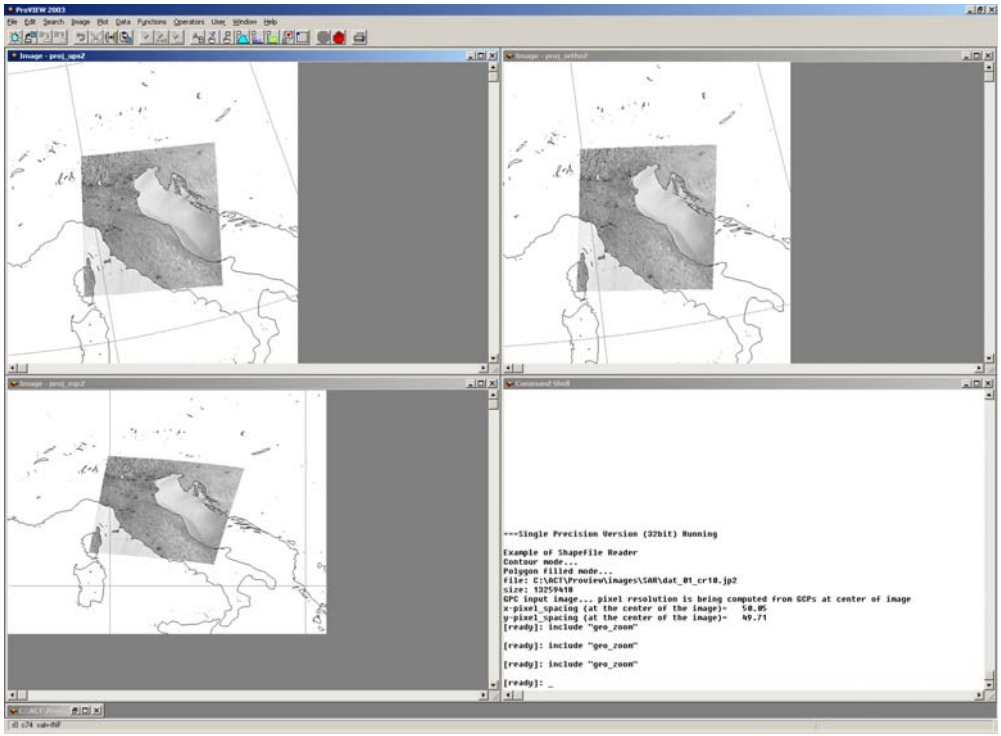


Figure 11 Map_Image.msf Sample ouput screen showing results in

The following sections provides detail on the low level functions in GDAL for which the are direct bindings from the MSHELL interpreter language.

ACT-REACT&MSHELLGDAL Library Support

$driver_list = **gdal_driver_init**()

Initializes the GDAL dataset drivers. Returns a list of registered dataset drivers. This must be done before accessing any of the GDAL related functions.

dataset_handle = **gdal_open**($dataset_name) or **gdal_open**($data_name,**RWMODE**)

Attempts to open a dataset with GDAL library and returns a non-zero dataset handle (integer number) which is used to reference that file in other functions. (in many cases *$dataset_name* is just a file name), RWMODE=0 for opening on read only mode, and RWMODE=1 for opening using write/update mode. If RWMODE is omitted, then it is set to 0, i.e. read-only.

gdal_close(dataset_handle)

Closes the dataset.

gdal_dataset_info(dataset_handle)

Returns some general information about the given open dataset_handle.

gdal_dataset_info_detail(dataset_handle)

Returns detailed information about the given open dataset_handle.

gdal_get_metadata(dataset_handle,"") or **gdal_get_metadata**(dataset_handle,"SUBDATASETS")

Returns metadata information

status = **gdal_set_metadata**(dataset_handle, $metadata_keys, $metadata_values)

Set metadata information. $metadata_keys contains the list of metadata keys to set while the correspondent values are provided in $metadata_values. Each element in the keys and values list must be separated by a new line. Returns 0 in case of success.

gdal_get_raster_size(dataset_handle)
Returns the raster size as a vector array: *bands::rows::columns.*

geo_xform = **gdal_get_geo_transform**(dataset_handle)

Returns the affine transformation coefficients as a vector array. These coefficients satisfy the following equations which transform between pixel/line (P,L) raster space, and projection coordinates (Xp,Yp) space:

```
P - pixel
L = line
Xp = geo_xform(0,0) + P* geo_xform(0,1) + L* geo_xform(0,2)
Yp = geo_xform(0,3) + P* geo_xform(0,4) + L* geo_xform(0,5)
```

gdal_set_geo_transform(dataset_handle, geo_xform)

Sets the affine transformation coefficients from a vector array. These coefficients satisfy the following equations which transform between pixel/line (P,L) raster space, and projection coordinates (Xp,Yp) space:

```
P = pixel
L = line
Xp = geo_xform(0,0) + P* geo_xform(0,1) + L* geo_xform(0,2)
Yp = geo_xform(0,3) + P* geo_xform(0,4) + L* geo_xform(0,5)

Or in MSHELL notation, geo_xform is
      geo_xform = xmin::dx::0::ymax::0::-dy.abs
```

$proj_ref = **gdal_get_projection_ref**(hdl)

Returns the projection definition string for the dataset. The return string defines the projection coordinate system of the image in OpenGIS WKT format. It should be suitable for use with the OGRSpatialReference functions.

status = **gdal_set_projection**(hdl, $proj_ref)

Set the projection reference string for this dataset.

The string should be in OGC WKT or PROJ.4 format. An error may occur because of incorrectly specified projection strings, because the dataset is not writable, or because the dataset does not support the indicated projection. Many formats do not support writing projections. Some formats do not support PROJ.4 strings directly. Convert to WKT with OGRSpatialReference functions first.

gcps = **gdal_get_gcps**(hdl)

Returns the internal Ground Control Points (GCPs) for the dataset as a Nx5 array where N is the number of GCPs, and the 5 columns are arranged as follows:

line::pixel::X::Y::Z

gdal_set_gcps(hdl,geo_xform,$WKT)

Sets the ground control points (GCPs). 'geo_xform' contains the geo-transformation, and '$WKT' is the as string with the OGC Well-lknown-Text, that provides the spatial-reference-system to be associated with the ground control points. ??????

$gcp_proj = **gdal_get_gcp_projection**(hdl)

Returns the projection space (a WKT string) for the X,Y,Z values returned from *gdal_get_gcps()*.

count = **gdal_get_overview_count**(hdl,band)

Returns the number of overview layers available.

ctable = **gdal_get_raster_color_table**(hdl,bandnum)

Returns an array with the color table.

$des = **gdal_get_raster_description** (hdl, bandnum)

Returns the description for this band number.

status = **gdal_set_raster_description** (dataset_handle, bandnum, $des)

Set the description for the specified band number. Returns 0 in case of success.

ndatav = **gdal_get_raster_no_data_value**(hdl, bandnum)

Returns the 'no-data-value' for this band number.

status = **gdal_set_raster_no_data_value** (dataset_handle, bandnum, no_data_value)

Set the ‘no-data value’ for the specified band number. Returns 0 in case of success.

offset = **gdal_get_raster_offset**(hdl,bandnum)

Fetch the raster value offset.

This value (in combination with the **gdal_get_raster_scale**( ) value) is used to transform raw pixel values into the units returned by gdal_get_raster_unit_type().

Units value = (raw value * scale) + offset

For file formats that don't know this intrinsically a value of zero is returned.

ctable = **gdal_get_raster_data_type**(hdl,bandnum)

Returns the pixel data type for this band. See gdal_create( ) for a description of the data types.

ctable = **gdal_get_raster_scale**(hdl,bandnum)

Fetch the raster value scale.

This value (in combination with the **gdal_get_raster_offset**( ) value) is used to transform raw pixel values into the units returned by gdal_get_raster_unit_type().

Units value = (raw value * scale) + offset

For file formats that don't know this intrinsically a value of zero is returned.

$unit = **gdal_get_raster_unit_type**(hdl,bandnum)

Returns a string with the unit type for this raster band.

gdal_rasterio(hdl, wf, xoff, yoff, xsize, ysize, my_array, band_map, npix_spc, nline_spc, nband_spc)

hdl	handle for an open dataset
wf	write flag (1 for write, 0 for read)

xoff	raster x offset
yoff	raster y offset
xsize	pixel width to read/write
ysize	pixel height to read/write
my_array	array to read or write
band_map	vector array of band numbers to read/write
npix_spc	interpixel spacing in bytes (0 = default, datatype size)
nline_spc	interline spacing in bytes (0 = default, datatype size * buffer width)
nband_spc	interband spacing in bytes (0 = default, nline_spc * (buffer height/nbands requested))

If xsize or ysize is different than the size of *my_array*, the GDAL library will decimate, or replicate to fit the *my_array* buffer.

The float (or double) data in my_array will be converted (just clipping and casting, values not scaled!) to whatever data type the dataset is defined to be.

new_hdl = **gdal_create_copy**($driver_name,$filename,hdl, options)

Creates a new GDAL dataset in *$filename* using existing open dataset referenced by *hdl*.
The *$driver_name* is the "short" name for the dataset format, which are shown in the output of the *gdal_driver_info()* function.
The *options* are for future general, and format specific options.
Returns a new dataset handle (may be read-only)

hdl_new = **gdal_create**($driver_name,$filename,size_vector,datatype_code,0)

Creates a new GDAL dataset from scratch.
The *$driver_name* is the "short" name for the dataset format, which are shown in the output of the *gdal_driver_info()* function.
The *size_vector* should always be 3 values given as: *bands::rows::columns*.
The *datatype_code* is the pixel datatype code used by GDAL:

```
GDT_Byte = 1,
GDT_UInt16 = 2,
GDT_Int16 = 3,
GDT_UInt32 = 4,
GDT_Int32 = 5,
GDT_Float32 = 6,
GDT_Float64 = 7,
GDT_CInt16 = 8,
GDT_CInt32 = 9,
GDT_CFloat32 = 10,
GDT_CFloat64 = 11
```

status = **gdal_build_overviews**(hdl,$resampling_method,overview_list,band_list)

Creates overviews for the dataset if the driver for that dataset supports them.

hdl – dataset handle
$resampling_method – “AVERAGE”, “NEAREST”, …others in future?
overview_list – vector of reduction factors to use creating overviews
band_list – vector of bands to generate overviews for (band #’s start at 1)

status = gdal_contour_generate (hdl, band,contour_interval,contour_base, fixed_level_count,fixed_levels,use_nodata,$shapefile,$attr_name,use_3d)

hdl	handle for an open dataset
contour_interval	The elevation interval between contours generated.
contour_base	The "base" relative to which contour intervals are applied. This is normally zero, but could be different. To generate 10m contours at 5, 15, 25, ... the ContourBase would be 5.
fixed_level_count	The number of fixed levels. If this is greater than zero, then fixed levels will be used, and ContourInterval and ContourBase are ignored.
fixed_levels	The list of fixed contour levels at which contours should be generated. It will contain FixedLevelCount entries, and may be NULL if fixed levels are disabled (FixedLevelCount = 0).
use_nodata	If this is 1, and if the dataset band has a nodata value associated with it, the nodata value will be honoured. That is, no contours will be generated for nodata pixels.
$shapefile	The name of the shapefile to generate. The name does not require an extension (the .shp, .shx, .dbf, and .prj extensions will be added as needed). If the shapefile already exists, it will be deleted and a new one created.
$attr_name	The name of the attribute that should be created in the shapefile and used for elevations. This may be NULL if no elevation attribute is required.
use_3d	1 if the produced shapefile should be 3D, with the contour elevation associate with each vertex in the file. Note that 3D shapefiles are not nearly as widely supported by applications as 2D shapefiles.

Example: see example in function shape2contour.

status = gdal_fill_nodata($filename, band, $maskfilename, max_search_dist, num_smoothing_iterations, options, $odriver, $ofilename)

Fill selected raster regions by interpolation from the edges. This algorithm will interpolate values for all designated nodata pixels (marked by zeros in the source mask). For each pixel a four direction

conic search is done to find values to interpolate from (using inverse distance weighting). Once all values are interpolated, zero or more smoothing iterations (3x3 average filters on interpolated pixels) are applied to smooth out artifacts.
This algorithm is generally suitable for interpolating missing regions of fairly continuously varying rasters (such as elevation models for instance). It is also suitable for filling small holes and cracks in more irregularly varying images (like airphotos). It is generally not so great for interpolating a raster from sparse point data.

$filename	the source raster file.
band	the source raster file band to be interpolated.
$maskfilename	use the first band of the specified file as a valid mask (zero is invalid, non-zero is valid). If an empty string is specified then a default validity mask is created using the source raster band no data value.
max_search_dist	the maximum distance (in pixels) that the algorithm will search out for values to interpolate.
num_smoothing_iterations	the number of 3x3 average filter smoothing iterations to run after the interpolation to dampen artifacts.
options	not used now. Just pass 0.
$odriver	output format. Use the short format name.
$ofilename	the new file to create with he interpolated result.

ACT-REACT&MSHELL OGR (within GDAL) Library Support

osr_hdl = **osr_new_spatial_reference**($WKT)

Creates a new OpenGIS Spatial Reference System (**SRS**) object and returns a handle to this object. The input $WKT is optional. An empty string can be passed.

status = **osr_destroy_spatial_reference**(osr_hdl)

Destroys the SRS object.

status = **osr_import_from_proj4**(osr_hdl, $proj4)

Import PROJ.4 coordinate string. The OpenGIS Spatial Reference object is initialized from the passed PROJ.4 style coordinate system string.

Example: pszProj4 = "+proj=utm +zone=11 +datum=WGS84"

$WKT = **osr_export_to_wkt**(osr_hdl)

Returns the WKT string for this SRS.

$proj4 = **osr_export_to_proj4**(osr_hdl)

Returns the PROJ.4 string for this SRS.

linear_units = **osr_get_linear_units**(osr_hdl)

Returns the value to multiply by linear distances to transform them to meters. If no units are available, a value of "Meters" and 1.0 will be assumed.

value = **osr_get_semi_major**(osr_hdl)

Returns the spheroid semi major axis or WGS84 semi major axis if it cannot be found.

value = **osr_get_semi_minor**(osr_hdl)

Returns the spheroid semi minor axis or WGS84 semi minor axis if it cannot be found.

Table 2 GDAL Supported Raster Formats (see http://www.remotesensing.org/gdal/formats_list.html updates)

Long Format Name	Code	Creation	Georeferencing	Accessbile From MSHELL	Maximum file size[1]
Arc/Info ASCII Grid	AAIGrid	Yes	Yes		No limits
Arc/Info Binary Grid (.adf)	AIG	No	Yes		--
Microsoft Windows Device Independent Bitmap (.bmp)	BMP	Yes	Yes		4GiB
BSB Nautical Chart Format (.kap)	BSB	No	Yes		--
CEOS (Spot for instance)	CEOS	No	No		--
First Generation USGS DOQ (.doq)	DOQ1	No	Yes		--
New Labelled USGS DOQ (.doq)	DOQ2	No	Yes		--
Military Elevation Data (.dt0, .dt1)	DTED	No	Yes		--
ERMapper Compressed Wavelets (.ecw)	ECW	Yes	Yes		
ESRI .hdr Labelled	EHdr	No	Yes		--
ENVI .hdr Labelled Raster	ENVI	Yes	Yes		No limits
Envisat Image Product (.n1)	Envisat	No	No		--
EOSAT FAST Format	FAST	No	Yes		--
FITS (.fits)	FITS	Yes	No		
Graphics Interchange Format (.gif)	GIF	Yes	No		
Arc/Info Binary Grid (.adf)	GIO	Yes	Yes		
GRASS Rasters	GRASS	No	Yes		--
TIFF / GeoTIFF (.tif)	GTiff	Yes	Yes		4GiB
Hierarchical Data Format Release 4 (HDF4)	HDF4	Yes	Yes		2GiB
Erdas Imagine (.img)	HFA	Yes	Yes		No limits[2]
Atlantis MFF2e	HKV	Yes	Yes		No limits
Japanese DEM (.mem)	JDEM	No	Yes		--
JPEG JFIF (.jpg)	JPEG	Yes	Yes		4GiB (max dimentions 65500x65500)
JPEG2000 (.jp2, .j2k)	JPEG2000	Yes	Yes		
JPEG2000 (.jp2, .j2k)	JP2KAK	Yes	Yes		
NOAA Polar Orbiter Level 1b Data Set (AVHRR)	L1B	No	Yes		--
Atlantis MFF	MFF	Yes	Yes		No limits
Multi-resolution Seamless Image Database	MrSID	No	Yes		--
NITF	NITF	Yes	Yes		
OGDI Bridge	OGDI	No	Yes		--
PCI .aux Labelled	PAux	Yes	No		No limits
Portable Network Graphics (.png)	PNG	Yes	No		
Netpbm (.ppm,.pgm)	PNM	Yes	No		No limits
USGS SDTS DEM (*CATD.DDF)	SDTS	No	Yes		--
SAR CEOS	SAR_CEOS	No	Yes		--
USGS ASCII DEM (.dem)	USGSDEM	No	Yes		--
X11 Pixmap (.xpm)	XPM	Yes	No		

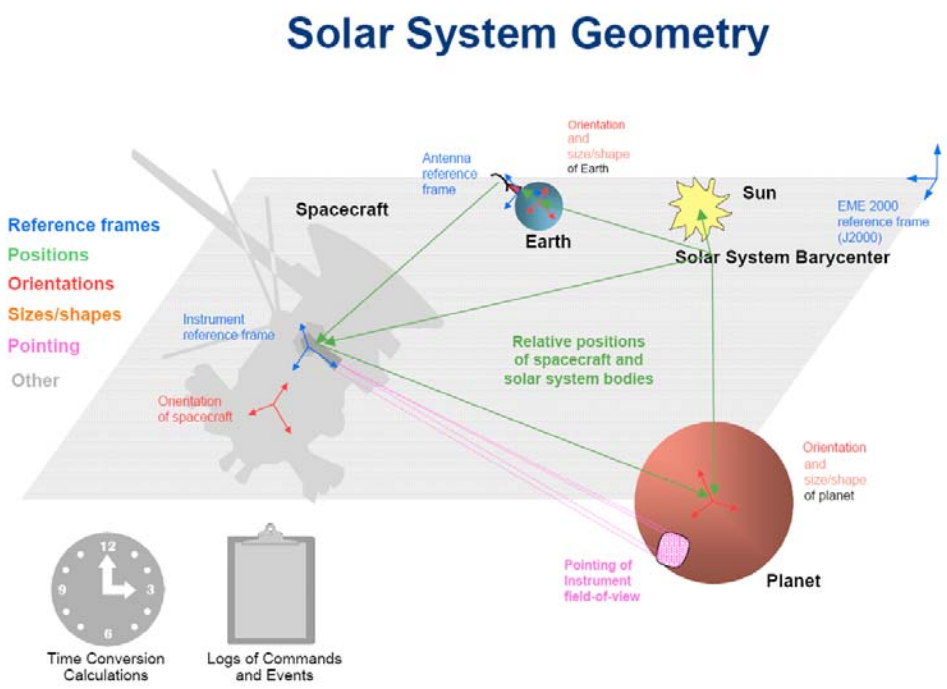
[1]Maximum file size does not only determined by the file format itself, but operating system/file system capabilities as well. Look **here** for details.
[2]ERDAS Imagine has different file format for large files, where 32-bit pointers cannot be used. Look for details **here**.

Appendix F: SPICE Bindings

SPICE Brief Overview

JPL's Navigation and Ancillary Information Facility (NAIF) provides NASA planetary flight projects and NASA funded professional planetary researchers an information system named "SPICE" to assist scientists in planning and interpreting scientific observations from space-borne instruments. SPICE is also widely used in engineering tasks associated with planetary missions.

SPICE is focused on **solar system geometry.** The SPICE system includes a large suite of software, mostly in the form of subroutines, that customers incorporate in their own application programs to read SPICE files and to compute derived observation geometry, such as altitude, lattitude/longitude, and lighting angles.



Reference

Acton, C.H.; "Ancillary Data Services of NASA's Navigation and Ancillary Information Facility;" Planetary and Space Science, Vol. 44, No. 1, pp. 65-70, 1996.

ACT has been doing extensive use of the SPICE system in direct support of different planetary missions, e.g. CLEMENTINE, STARDUST, DeepImpact, MESSENGER, MRO/CRISM, M3, MSTI2&3, etc.

The following sub-sections discusses function bindings that have been created from ACT-REACT&MSHELLinto SPICE.

Special Acknowledgement:

ACT likes to specially thank the NAIF/SPICE team for all the great work it has been done in the implementation/maintenance of SPICE and for making this library available to the overall community.

SPICE Software Disclaimer follows (**from rules of usage follows**) :

> THIS SOFTWARE AND ANY RELATED MATERIALS WERE CREATED BY THE CALIFORNIA INSTITUTE OF TECHNOLOGY (CALTECH) UNDER A U.S. GOVERNMENT CONTRACT WITH THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA). THE SOFTWARE IS TECHNOLOGY AND SOFTWARE PUBLICLY AVAILABLE UNDER U.S. EXPORT LAWS AND IS PROVIDED "AS-IS" TO THE RECIPIENT WITHOUT WARRANTY OF ANY KIND, INCLUDING ANY WARRANTIES OF PERFORMANCE OR MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE OR PURPOSE (AS SET FORTH IN UNITED STATES UCC§2312-§2313) OR FOR ANY PURPOSE WHATSOEVER, FOR THE SOFTWARE AND RELATED MATERIALS, HOWEVER USED.

ACT-REACT&MSHELL SPICE Interface

ACT has been doing extensive use of the SPICE system as part of our direct support of different NASA planetary missions, e.g. CLEMENTINE, STARDUST, DeepImpact, MESSENGER, MRO/CRISM, M3, MSTI2&3, etc.

The following discusses some of the SPICE library functionalities (in particular the CSPICE version) that are presently accessible from the ACT-REACT&MSHELL scripting language.

*Generally ACT-REACT & MSHELL-SPICE functions follow the syntax of the original CSPICE interface. But, when appropriate, **we have vectorized some of the functions** to perform the same SPICE operation over a set of input data on a row-wise fashion.*

Notes:

1. In the following '[*]x' means that the 'x' it is an output variable, that needs to be initialized before calling the function.
2. **Examples for all the implemented functions** can be found in the following include script, (ACT-REACT) /scripts/spice/m2spice_examples.msh

ACT-REACT&MSHELLSPICE Support

Toolkit management

m2spice_init ( )

Initialize MSHELL/SPICE environment. This function needs to be called once before calling any other MSHELL/SPICE function.

status **= m2spice_failed ( )**

Interface to SPICE function *failed _c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/failed_c.html**)
It returns 0 upon successful, a non-zero value if an error occured (the .text attribute contains a brief description of the error).

m2spice_reset ( )

Interface to SPICE function *reset_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/reset_c.html**)
Reset any error condition that has happened on previous call to one of the MSHELL/SPICE functions.

m2spice_tkvrsn ($item)

Interface to SPICE function *tkvrsn_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/tkvrsn_c.html**)
Given an item such as the "Toolkit" or an entry point name, returns the latest version string.

Kernels management

status = **m2spice_furnsh (** $fname **)**

Interface to SPICE function *furnsh_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/furnsh_c.html**)
Load SPICE kernels or meta-kernel list via the KEEPER interface from text or binary file. It returns 0 upon successful, a non-zero value if an error occurs (the .text attribute contains a brief description of the error).

m2spice_kclear ( )

Interface to SPICE function *kclear_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/kclear_c.html**)
Clear the KEEPER system: unload all kernels, clear the kernel pool, and re-initialize the system.

status = **m2spice_ktotal (** $kind **)**

Interface to SPICE function *ktotal_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ktotal_c.html**)
Return the number of loaded kernels that have been loaded by 'm2spice_furnsh' that are of the '$kind' specified type or -1 if failed. In the latter case the .text attribute contains a brief description of the error.

data = **m2spice_kdata (** which, $kind **)**

Interface to SPICE function *kdata_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/kdata_c.html**)
Return some information about a given kernel, loaded using the 'm2spice_furnsh' that is of the '$kind' specified type or -1 if failed.
The information is retrieved for the kernel specified by the first argument which is an index between 0 and the value returned by the 'm2spice_ktotal($kind)' minus one.

The .text attribute of the returned value contains three lines as follows:

Kernel file, e.g.: spk/msgr_20040803_20120401_od125sc.bsp
Kernel type, e.g.: SPK
Kernel source: e.g.: kernelsMESSENGER.satview

coverage = **m2spice_ckcov ($**ck, idcode, needav, $level, tol, $timsys, timeinterval **)**

Interface to SPICE function *ckcov_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ckcov_c.html**)
Find the coverage window for the specified object 'idcode' in a specified CK file '$ck'.

NAIF IDs - Names - Values

frmcode = **m2spice_cnmfrm (** $cname **)**

Interface to SPICE function *cnmfrm_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/cnmfrm_c.html**)
Return the frame ID code and the name (max 80 characters as the .text attribute) associated with the specified '$cname' object. It returns a NULL ARRAY if it cannot find the requested information.

dpvalues = **m2spice_bodvrd (** $bodynm, $item, maxn **)**

Interface to SPICE function *bodvrd_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/bodvrd_c.html**)
Fetch from the kernel pool the double precision values of an item associated with a body and returns such values as a row vector ARRAY variable. It returns a NULL ARRY if it fails retrieving d.p. values. For example, this function can be used to retrieve the radius vector associated to a planet.

code = **m2spice_bodn2c (** $name **)**

Interface to SPICE function *bodn2c_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/bodn2c_c.html**)
Translate the name of a body or object to the corresponding SPICE integer ID code and return it. If the name was not found it returns a NULL ARRAY.

values = **m2spice_gdpool(** $name, start, room **)**

Interface to SPICE function *gdpool_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/gdpool_c.html**)

Fetch double precision values of a kernel variable from the kernel pool. If the variable name is not found returns a NULL ARRAY, otherwise returns a row vector containing the values.
The user has to specify the maximum number of values to be returned (room), and the starting index (start) within the kernel variable (use 0 here as start value to get all the values).

Retrieving Instrument Parameters (IK)

fov = **m2spice_getfov (** instid, room_n, [*] bsight, [*] shape, [*] frame **)**

Interface to SPICE function *getfov_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/getfov_c.html**)
Compute the field-of-view (FOV) configuration for a specified instrument ('instid') and return the FOV boundary vectors as an *m* x 3 matrix ARRAY variable (or -1 if it fails). *m* will be less or equal to 'room_n'. It also returns the boresight vector ('bsight', row vector ARRAY variable of 3 element), the instrument FOV shape (.text attribute of 'shape') and the name of the frame in which FOV vectors are defined (.text attribute of 'frame'). For both the instrument FOV shape and the name of the frame, the maximum length of the returned string can be specified in 'shape' and 'frame' ARRAY variables. If the value of -1 is specified the maximum length of 40 characters is assumed.

Converting between Ephemeris Time and UTC

m2spice_et2utc (et, $format, prec, [*] utc_out **)**

Interface to SPICE function *et2utc_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/et2utc_c.html**)
Convert an input time from ephemeris seconds past J2000 to Calendar, Day-of-Year, or Julian Date format, UTC and return the string as the .text attribute of the output ARRAY variable 'utc_out'. The maximum length of the returned string can be specified as a scalar value in 'utc_out'. If -1 is specified the maximum length of 40 characters is assumed.

m2spice_et2utc_vec (et, $format, prec, [*] utc_out **)**

Vectorized version of 'm2spice_et2utc'. Convert multiple input times ('et' is a column vector of *m* elements) from ephemeris seconds past J2000 to Calendar, Day-of-Year, or Julian Date format, UTC. Converted strings (1 string per line) are returned as the .text attribute of the output ARRAY variable 'utc_out'. The maximum length of the each returned string can be specified as a scalar value in 'utc_out'. If -1 is specified the maximum length of 40 characters is assumed.

Converting between UTC and Ephemeris Time (LSK)

et = **m2spice_str2et (** $str **)**

Interface to SPICE function *str2et_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/str2et_c.html**)
Convert a string representing an epoch and return a double precision value representing the number of TDB seconds past the J2000 epoch corresponding to the input '$str' epoch string. It returns -1 if the conversion failed and the .text attribute contains a brief description of the error.

Converting between Ephemeris Time and Spacecraft Clock

et = **m2spice_scs2e (** sc, $sclkch **)**

Interface to SPICE function *scs2e_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/scs2e_c.html**)
Convert a spacecraft clock string to ephemeris seconds past J2000 and return such value. It returns -1 if the conversion failed and the .text attribute contains a brief description of the error.

et = **m2spice_scs2e_vec (** sc, $sclkch **)**

Vectorized version of 'm2spice_scs2e'. Convert multiple spacecraft clock strings ('$sclkch' is a string list that has 1 spacecraft clock sting per line) to the corresponding ephemeris seconds past J2000 and return such values as column vector ARRAY variable. Whenever the conversion has failed a value of -1 is returned as part of the output column vector.

Converting between Spacecraft Clock and Ephemeris Time

$sclkch = **m2spice_sce2s (** sc, et **)**

Interface to SPICE function *scs2e_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/sce2s_c.html**)
Convert an epoch specified as ephemeris seconds past J2000 to a spacecraft clock string. It returns a NULL string if the conversion failed.

$sclkch = **m2spice_sce2s_vec (** sc, et **)**

Vectorized version of 'm2spice_sce2s'. Convert multiple epochs ('et' is a column vector) to the corresponding spacecraft clock strings and return them as a multiple lines string. Whenever the conversion fails an empty line will be returned as part of the output string.

Computing Positions of Spacecraft and Natural Bodies

m2spice_spkpos ($targ, et, $ref, $abcorr, $obs, [*] ptarg, [*] lt **)**

Interface to SPICE function *spkpos_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkpos_c.html**)
Return the position of a target body ('ptarg', row vector ARRAY variable of 3 element) relative to an observing body, optionally corrected for light time (planetary aberration) and stellar aberration ('lt', scalar).

m2spice_spkgeo (targ, et, $ref, obs, [*] state, [*] lt **)**

Interface to SPICE function *spkgeo_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/spkgeo_c.html**)
Compute the geometric state (position and velocity) of a target body relative to an observing body.

Converting from and to rectangular coordinates

m2spice_reclat (rectan, [*] radius, [*] lon, [*] lat **)**

Interface to SPICE function *reclat_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/reclat_c.html**)
Convert from rectangular coordinates to latitudinal coordinates ('radius', 'lon' and 'lat', all scalars).

latitud = **m2spice_reclat_vec (** rectan **)**

Vectorized version of 'm2spice_reclat'. Perform multiple row-wise conversions from rectangular coordinates to latitudinal coordinates and return an *m* by 3 matrix ARRAY variable where each row is '*radius::lon::lat*'.

m2spice_latrec (radius, lon, lat, [*] rectan **)**

Interface to SPICE function *latrec_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/latrec_c.html**)
Convert from latitudinal coordinates to rectangular coordinates ('radius', 'lon' and 'lat', all scalars).

rectan = **m2spice_latrec_vec (** latitud **)**

Vectorized version of ‘m2spice_latrec’. Perform multiple row-wise conversions from latitudinal coordinates to rectangular coordinates and return an *m* by 3 matrix ARRAY variable where each row is ‘*x::y::z*’.

m2spice_recgeo (rectan, re, f, [*] lon, [*] lat, [*] alt **)**

Interface to SPICE function *recgeo_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/recgeo_c.html**)
Convert from rectangular coordinates to geodetic coordinates (‘lon’, ‘lat’ and ‘alt’, all scalars).

geodetic = **m2spice_recgeo_vec (** rectan, re, f **)**

Vectorized version of ‘m2spice_recgeo’. Perform multiple row-wise conversions from rectangular coordinates to geodetic coordinates and return an *m* by 3 matrix ARRAY variable where each row is ‘*lon::lat::alt*’.

m2spice_georec (lon, lat, alt, re, f, [*] rectan **)**

Interface to SPICE function *georec_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/georec_c.html**)
Convert from geodetic coordinates to rectangular coordinates (‘lon’, ‘lat’ and ‘alt’, all scalars).

rectan = **m2spice_georec_vec (** geodetic, re, f **)**

Vectorized version of ‘m2spice_georec’. Perform multiple row-wise conversions from geodetic coordinates to rectangular coordinates and return an *m* by 3 matrix ARRAY variable where each row is ‘*x::y::z*’.

m2spice_recrad (rectan, re, f, [*] range, [*] ra, [*] dec **)**

Interface to SPICE function *recrad_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/recrad_c.html**)
Convert from rectangular coordinates to range (‘range’, scalar), right ascension (‘ra’, scalar) and declination (‘dec’, scalar).

rad = **m2spice_recrad_vec (** rectan **)**

Vectorized version of ‘m2spice_recrad’. Perform multiple row-wise conversions from rectangular coordinates to range, right ascension and declination and return an *m* by 3 matrix ARRAY variable where each row is ‘*range::ra::dec*’.

m2spice_radrec (range, ra, dec, [*] rectan **)**

Interface to SPICE function *radrec_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/radrec_c.html**)
Convert from range (‘range’, scalar), right ascension (‘ra’, scalar) and declination (‘dec’, scalar) to rectangular coordinates.

rectan = **m2spice_radrec_vec (** rad **)**

Vectorized version of ‘m2spice_radrec’. Perform multiple row-wise conversions from range, right ascension and declination to rectangular coordinates and return an *m* by 3 matrix ARRAY variable where each row is ‘*x::y::z*’.

Computing Sub-observer and Sub-solar Points

m2spice_subpnt ($method, $target, et, $fixref, $abcorr, $obsrvr, [*] spoint, [*] trgepc, [*] srfvec **)**

Interface to SPICE function *subpnt_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/subpnt_c.html**)
Compute the rectangular coordinates of the sub-observer point on a target body at a specified epoch, optionally corrected for light time and stellar aberration.

m2spice_subpnt_vec ($method, $target, et, $fixref, $abcorr, $obsrvr,
[*] spoint, [*] trgepc, [*] srfvec **)**

Vectorized version of ‘m2spice_subpnt’. Perform multiple row-wise computations of the rectangular coordinates of the sub-observer point on a target body at a specified epoch, optionally corrected for light time and stellar aberration. Whenever the computation has failed a value of -999 is returned as part of the output column vector ‘trgepc’.

m2spice_subslr ($method, $target, et, $fixref, $abcorr, $absrvr, [*] spoint, [*] trgepc, [*] srfvec **)**

Interface to SPICE function *subslr_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/subslr_c.html**)
Compute the rectangular coordinates of the sub-solar point on a target body at a specified epoch, optionally corrected for light time and stellar aberration.

m2spice_subslr_vec ($method, $target, et, $fixref, $abcorr, $absrvr,
[*] spoint, [*] trgepc, [*] srfvec **)**

Vectorized version of ‘m2spice_subslr’. Perform multiple row-wise computations of the rectangular coordinates of the sub-solar point on a target body at a specified epoch, optionally corrected for light time and stellar aberration. Whenever the computation has failed a value of -999 is returned as part of the output column vector ‘trgepc’.

Computing Transformations Between Frames (FK)

rotate = **m2spice_pxform (** $from, $to, et **)**

Interface to SPICE function *pxform_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/pxform_c.html**)
Return the matrix that transforms postion vectors from one specified frame to another at a specified epoch as a 3x3 matrix ARRAY variable or -1 if it fails (the .text attribute contains a brief description of the error).

Computing Surface Intercept Point

state = **m2spice_sincpt (** $method, $target, et, $fixref, $abcorr, $absrvr, $dref, $dvec,
[*] spoint, [*] trgepc, [*] srfvec **)**

Interface to SPICE function *sincpt_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/sincpt_c.html**)
Given an observer and a direction vector defining a ray, compute the surface intercept of the ray on a target body at a specified epoch, optionally corrected for light time and stellar aberration. It returns 0 upon successful, a non-zero value if an error occurs (the .text attribute contains a brief description of the error).

state = **m2spice_sincpt_vec (** $method, $target, et, $fixref, $abcorr, $absrvr, $dref, $dvec,
[*] spoint, [*] trgepc, [*] srfvec **)**

Vectorized version of ‘m2spice_sincpt’.Given an observer and for each direction vector defining a ray, perform multiple row-wise computation of the surface intercept of the ray on a target body at each specified epoch, optionally corrected for light time and stellar aberration. For each computation it returns 0 upon successful, a non-zero value if an error occurs.

m2spice_npedln (ellaxis, linept, linedir, pnear, dist**)**

Interface to SPICE function *npedln_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/npedln_c.html**)

Find the nearest point on a triaxial ellipsoid to a specified line, and the distance from the ellipsoid to the line. The 3 ellipsoid semi-axes are specified in *ellaxis* (1x3), The line is specified by a point (*linept*, 1x3) and a direction (*linedir*, 1x3).
The resulting nearest point on the surface is put in *pnear* (1x3) and *dist* (1x1) will be the distance to the line.

found = **m2spice_surfpt (** position, u, a, b, c, [*] point**)**

Interface to SPICE function *surfpt_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/surfpt_c.html**)
Determine the intersection of a line-of-sight vector (*position* of the observer and direction vector *u*) with the surface of an ellipsoid given by the x/y/z semiaxis *a*, *b* and *c*. Returns 0 if the intercept was found and *point* contains the coordinate of the intersection; -1 if not. Any other returned value denotes an error and the returned text attribute contains a brief description of the error.

found = **m2spice_surfpt_vec (** position, u, a, b, c, [*] point**)**

Vectorized version of ‘m2spice_surfpt’. Perform multiple row-wise computation to determine the intersection of a line-of-sight vector (each row of *position* is the position of the observer and each row of *u* is the direction vector) with the surface of an ellipsoid given by the x/y/z semiaxis *a*, *b* and *c*. Return an *m* by 1 column vector where each row is the status of the intersection: 0 if found, -1 if not found, any other values for errors. In case of an intersection, the corresponding row in *point* contains the coordinates of the intersection point.

Computing Illumination Angles

m2spice_ilumin ($method, $target, et, $fixref, $abcorr, $absrvr, spoint,
[*] trgepc, [*] srfvec, [*] phase, [*] solar, [*] emissn **)**

Interface to SPICE function *ilumin_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/ilumin_c.html**)
Find the illumination angles (phase, solar incidence, and emission) at a specified surface point of a target body.

m2spice_ilumin_vec ($method, $target, et, $fixref, $abcorr, $absrvr, spoint,
[*] trgepc, [*] srfvec, [*] phase, [*] solar, [*] emissn **)**

Vectorized version of 'm2spice_ilumin'. For each specified surface point of a target body, compute (row-wise) the illumination angles (phase, solar incidence, and emission).

Creating and Converting Transformation Matrices

m2spice_m2eul (r, axis, [*] angle **)**

Interface to SPICE function *m2eul_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/m2eul_c.html**)
Factor a rotation matrix as a product of three rotations about specified coordinate axes (‘axis’ is a ‘axis3::axis2::axis1’ row vector ARRAY). It returns the third, second and first Euler angles (in radians) as a ‘*angle3::angle2::angle1*’ row vector ARRAY variable ‘angle’.

m2spice_eul2m (angle, axis, [*] r **)**

Interface to SPICE function *eul2m_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/eul2m_c.html**)
Construct a rotation matrix as a product of three rotations about specified coordinate axes (‘axis’ is a ‘axis3::axis2::axis1’ row vector ARRAY) from a set of Euler angles (in radians) as a ‘*angle3::angle2::angle1*’ row vector ARRAY variable ‘angle’.

m2spice_axisar (axis, angle, [*] r **)**

Interface to SPICE function *axisar_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/axisar_c.html**)
Construct a rotation matrix that rotates vectors by a specified angle (in radians) about a specified axis.

m2spice_raxisa (matrix, [*] axis, [*] angle **)**

Interface to SPICE function *raxisa_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/raxisa_c.html**)
Compute the axis of the rotation given by an input matrix and the angle of the rotation (in radians) about that axis.

Performing Simple Operations on 3x3 Matrices

result = **m2spice_mxv (** matrix, vector **)**

Interface to SPICE function *mxv_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/mxv_c.html**)
Multiply a matrix (3 by 3) by vector (row vector of 3 elements) and return the result matrix (3 by 3).

result **= m2spice_mxm (** matrix1, matrix2 **)**

Interface to SPICE function *mxm_c*
(**http://naif.jpl.nasa.gov/pub/naif/toolkit_docs/C/cspice/mxm_c.html**)
Multiply a matrix (3 by 3) by matrix (3 by 3) and return the result matrix (3 by 3).

Examples

Example of use of recrad wrapper:

```
/* input */
rectan              = ones(1, 3)

/* output */
range               = -999  // output in Km
ra                  = -999  // output in radians
dec                 = -999  // output in radians

m2spice_recrad( rectan, range, ra, dec )
print "range,ra,dec\n"
range
ra*45/atan(1)
dec*45/atan(1)
```

Example of use of reclat and recgeo wrappers (VECTORIZED version):

```
print "Note: reclat converts from rectangular coordinates to geocentric
coordinates.\n"
print "Note: recgeo converts from rectangular coordinates to geodetic
or planetographic coordinates.\n"

/* input */
re                  = 6378.2064 // clark equatorial radius of the
reference ellipsoid
f                   = 1.0 / 294.9787    //  (re-rp)/re; rp is polar
radius
i33                 = ident(3)
rectan              = re/100*( zeros(1, 3)#i33#-i33#(ones(3, 3)-
rmirror(i33))#ones(1, 3))

/* output recgeo */
geov                = m2spice_recgeo_vec( rectan, re, f )
print "\nx,y,z,lon_g,lat_g,alt (note: using planetographic
computations, see
http://pds.jpl.nasa.gov/documents/sr/stdref2003/stdref_030801.pdf \n"
rectan::( geov(:, 0)*45/atan(1) ) :: ( geov(:, 1)*45/atan(1) ) ::
geov(:, 2)

/* output reclat */
RadiusLonLat        = m2spice_reclat_vec( rectan )
print "\nx,y,z,lon_c,lat_c,Radius (note: using planetocentric
computations, see
http://pds.jpl.nasa.gov/documents/sr/stdref2003/stdref_030801.pdf \n"
rectan::( RadiusLonLat(:, 1)*45/atan(1) ) :: ( RadiusLonLat(:,
2)*45/atan(1) ) :: RadiusLonLat(:, 0)
```

Example of use of m2eul wrapper (i.e. factor a rotation matrix as a product of three rotations about specified coordinate axes):

```
/* input */
[r]                 =ROT3D[0,0,45]
axis                = 1::2::3

/* output */
angle               = -999 * ones(1, 3)

m2spice_m2eul( r, axis, angle )
print "the factorized angles are\n"
angle*45/atan(1)
if(max(angle.abs)<=1e-9){
                    print "\nwarning! error in factorization\n"
}
```

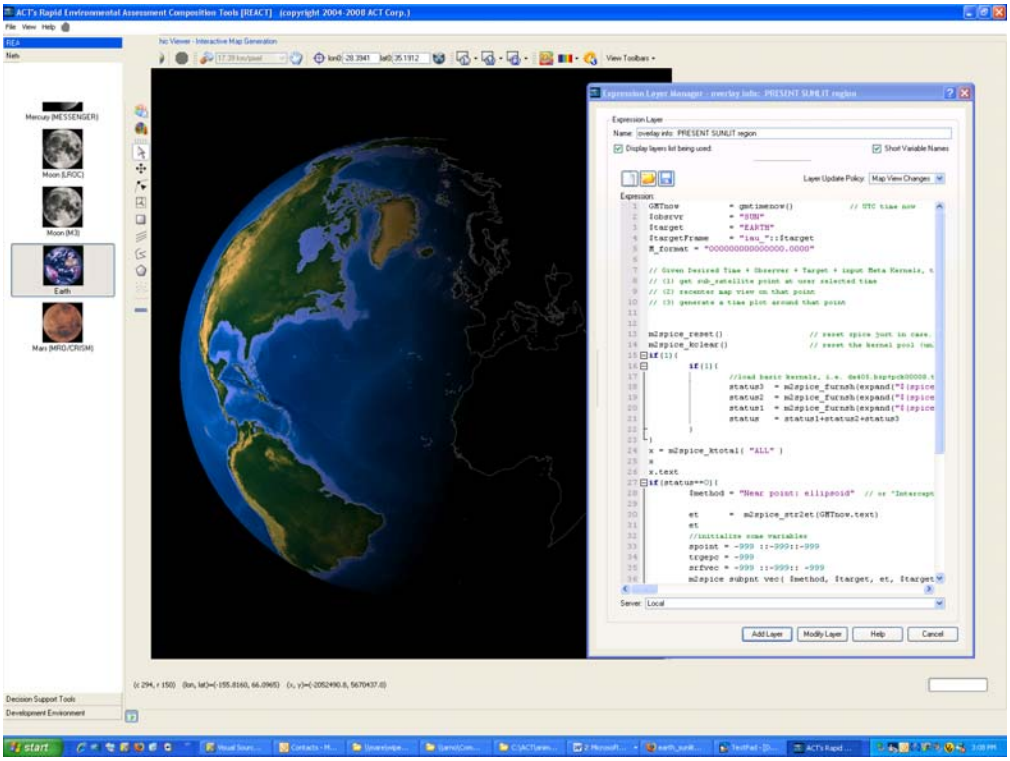


Figure 12 Example of using m2spice functions with ACT-REACT to show the present non-sunlit region on Earth as seen from an Geo-synchronous satellite.

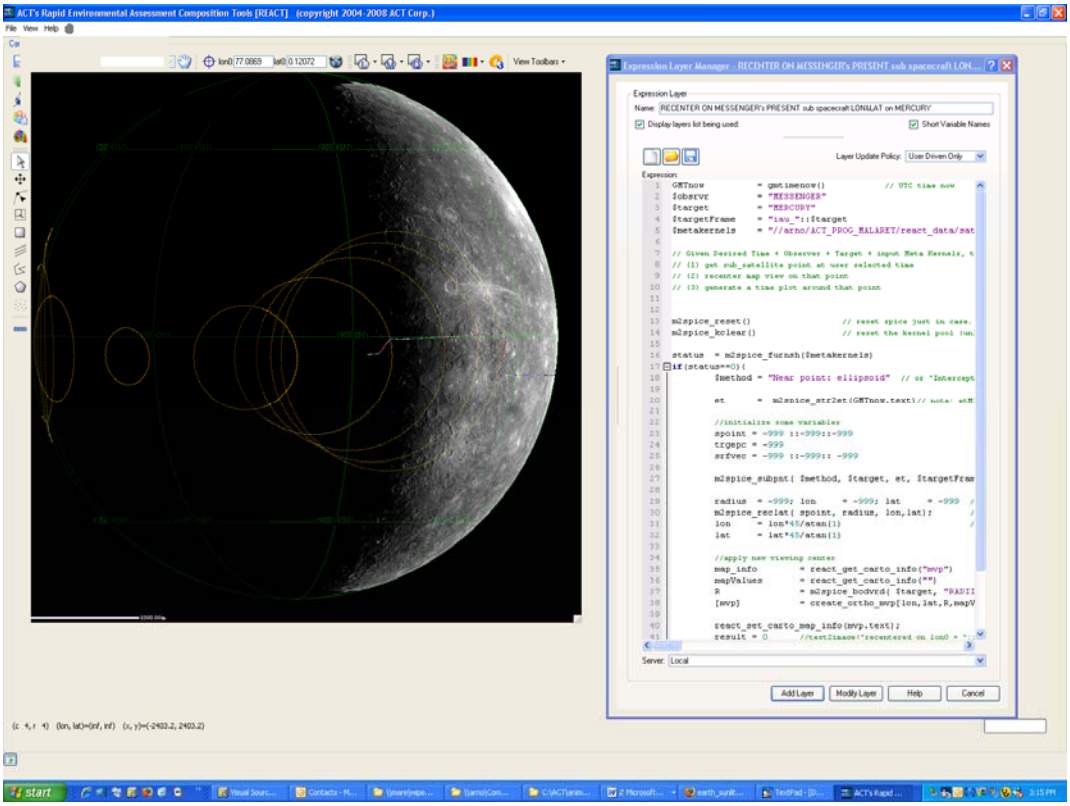


Figure 13 Example of using m2spice_ functions in ACT-REACT to show the present view of Mercury, as seen from the MESSENGER spacecraft, and simulate the non-sunlit region on Mercury. The image also shows coverage footprints from different instruments during the Mercury 1 Flyby. All geometry computations were done using the MSHELL to SPICE bindings. Note: *The MESSENGER data shown has been released to the public via PDS.*

Appendix G: RECENT CHANGES

List of Capabilities recently added to ACT-REACT/MSHELL

- Added table of index in the manual to all internal function. The index is by category of functions!
- Added **XML** parser
- 9/8/2002 - added M_no_data system variable
- 12/2002 – added M_logfile, and M_logmode
- Improved interface to NetCDF library
- Added interface to the CFITS library
- Added support for **double precision version** of MSHELL.
- Added support for **OpenGL**.
- Added interface to the USGS projection library (**PROJ4**)
- 5/2003 – Added **regulars expressions** capability, similar to Perl syntax
- Enhanced documentation with embedded examples
- Improved ODBC retrieval speed
- 2/2003 - **Ported MSHELL Interpreter to LINUX!**
- 3/2003 - Added M_processid system variable
- 4/2003 – Added support to writing geotiff files via writea()
- 5/2003 – added additional support to dworld such that vector shoreline can now be drawn on any supported USGS cartographic map projections.
- 5/2003 – added support to the KAKADU **JPEG2000 reader and writer**
- 6/2003 – Added support to the Geographic Data Abstraction Library (GDAL)
  ➔ **read/write support to:**
  GeoTiff, NITF, ERDAS, HDF, JPEG2000, NITF, CEOS,ENVISAT, …
- Incorporated **OpenGIS WKT** cartographic description methods

- 10/2003 – writea and reada will save and restore the x.text attribute
- 10/2003 – added support to perform raster two Shape-files conversion on large input files
- 10/2003 - added 'statsx' function, to allow statistics computation with exclusion of certain input values
- 11/11/2003 - added dbrsgetcolnames() function and improved database access
- 12/2004Added new set of mapping scripts.
  Map_Image.msf, Map_Images.msf, Map_Image_to_file.msf, …
  These functions can map project any GDAL supported input file.
- 2/13/04- added support for formatted 'float2str', i.e. float2str(x,$format)
- 2/17/2004- added 'stop_process($error_string)' function
- 3/22/2004- ladd2groi(a,groi,b) can support 'b' to be a row vector, very useful for implementing fast accumulators
- 3/2004 - added additional support for **CFITS** library
- 4/2004 - added capability to MSHELL to be under the control of a license server with floating licenses
- 4/2004 fixed documentation for functions menusel and iboxlist
- 7/2004 added example for function gdal_contour_generate
- 1/2005 added a number of additional function bindings between MSHELL and GDAL
- 2/2005 fixed documentation of view255
- 2/2005 added documentation for the 'x.LUT' image attribute which control image palettes.
- 3/2005 added support for a new raster reading function call, x = reada($input,"all"). This function tries to determine the input file type and read it. See also the new M_maxdim system variable.
- 4/2005 added new string manipulation functions, strEndsWith(), strStartsWith(), strContains().
- 4/2005 added volumetric handling capabilities for variables loaded in memory. See 'x.m_voltype', 'x.m_voldim', and the function 'alternateRGB()' plus 'alternateBSQ()'
- 4/2005 added documentation of gdal_get_metadata()
- 4/2005 added information for reading of voldim information, i.e. x.m_nrows3d, x.m_ncols3d, x.n_nband3d.
- 4/2005 added to interpreseter: strContains(), strEndsWith(), strStartWith(), strUniqueList… type of string functions (NOT documented yet)
- 5/2005 added function writeRGB($fname,r,g,b,$format), where $format can be "PNG" or "JPEG". This function is using a more portable approach to implement similar functionality as in writecolor().
- 5/2005 added x.mapinfo. It is similar to x.text, but it is used to track map_information.

- 7/2005 added maskofLT(),maskofGT, maskofGE(), maskofLE(), maskofEQ()
- 8/2005 added ftp_...., rw…., rmshell…. , getMyIP network related functions
- 8.2005 added sqlite_... , support
- 2.2005 added curvTraj(…) function.
- 6/2006 added support for bsq array IO, e.g. xyz(: | band) = [const or array]
- 3/2007 added readtext_and_status() function. Allows to control flow if the event that the readtext() fails.
- 1/2007 Added variable M_execution_mode. It allows to know which environment the script is running under. Provides more information than M_OS.
- 5/2007 Added new functions: allocate_array, url_copy_to_file, mshift_u16, mshift_u32, and, ACT-REACT_get_carto_info, ACT-REACT_set_carto_map_info.
- 9/2007 Added new functions: ACT-REACT_load_mlt, ACT-REACT_update_layers, ACT-REACT_enable_view, ACT-REACT_get_property, ACT-REACT_get_properties, ACT-REACT_set_property, polygonorient, sys_cat, ACT-REACT_open_url
- 2/2008 Added M_temp_unpid, M_appname variables. Added new functions: strStripWhitespace(), url_copy_to_stdout(), rmshell_ping_server(), rmshell_is_session_active()
- 5/2008 Added rmshell_putvars command. Changed name to some of the rmshell_... commands. Added command 'gui_getdir'
- 7/2008 Added plot_* MDI plotting functions
- 8/2008 Added bindings to many CSPICE functions
- 10/2008 added guiInfoTable function
- 10/2009 added react_open_cvdataprofiler, react_close_ cvdataprofiler, react_clear_ cvdataprofiler, react_close_dataprofile
- 01/2011 added find_key_points, find_matching_points
- 04/2011 added readtext with multiple parameters, readlinef, strTextSubset and sys_textfilelines
- 10/2011 added gdal_set_raster_no_data_value
- 03/2012 added m2spice_failed
- 04/2012 added gdal_set_raster_description and gdal_get_raster_description
- 05/2012 added convpolygonorient and gdal_fill_nodata
- 07/2013 added makegrid and makegridN
- 09/2013 added geo_get_*_list, tprofile*, alternate_bands_clear, get_finite_subarray, ogr_get_linear_units, ogr_get_semi_major and ogr_get_semi_minor

- 12/2013 added optional parameter “offset” to zinterp
- 01/2015 added image_outer_contour